Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

MOLLUSCA OF THE SOUTHWESTERN STATES: IV. THE CHIRICAHUA MOUNTAINS, ARIZONA.

BY H. A. PILSBRY AND J. H. FERRISS.

CONTENTS.

Introduction.

I. Conditions determining the isolation of snail colonies, p. 46.
II. Influence of environment on the shell, p. 47.
III. Factors in the formation of species and races, p. 49.
IV. Distribution of Chiricahuan mollusks, p. 50.
V. Systematic descriptions of species, p. 53.

The Chiricahua Mountains stand near the southeastern angle of Arizona, extending for about fifty miles from northwest to southeast, being one of the numerous short roughly parallel ranges of that part of New Mexico and Arizona. The Peloncillo range, lower and very arid, sharply limits the horizon eastward, distant about twenty miles. The next range westward is the Dragoon Mountains, fully thirty miles away. These ranges are separated by mesa having an elevation of about 5,000 feet, but lower in the middle.

The northwestern end of the range is known as the Dos Cabezas Mountains, being separated from the main range by a depression to 5,500 feet near Fort Bowie. The mountains as far south as White Tail Canyon are rather arid, the trees stunted oaks and piñons, with small beech, walnut, willow, buttonwood, etc., in the canyons. The Cave Creek region is much more verdant and at elevations of 8,000 feet and over there are fine pine and spruce forests.[1] The mountains are rugged, almost everywhere cut into sharp ridges and peaks, the slopes steep and stony or rocky, often broken by cliffs. The accompanying map gives a general idea of the positions of the various valleys or canyons mentioned herein. Various maps of single canyons give the locations of collecting stations.[2]

---

[1] For an account of the flora of the Chiricahuas see J. C. Blumer, The Plant Geography of the Chiricahua Mountains, *Science*, XXX, p. 720, November 19, 1909.

[2] The general map of the range and that of Cave Creek Canyon were drawn from sketches made by both authors, with some few additions to the general map from a map of the Chiricahua Forest Reserve, published by the Forest Service, U. S. Department of Agriculture, 1906. This map is very inaccurate in many details, yet useful in the absence of anything better. The other maps of canyons are from the note-book of one of the authors. Elevations where given herein are in part from the Forest Reserve map, in part estimated; and all must be accepted as only approximate.

The highest part of the range, and that florally and faunally richest, has been included since 1906 in a U. S. Forest Reserve; the rest of the range has no timber large enough to tempt the lumberman, and serves as cattle ranges. The conditions of molluscan life are likely to remain undisturbed for many years.

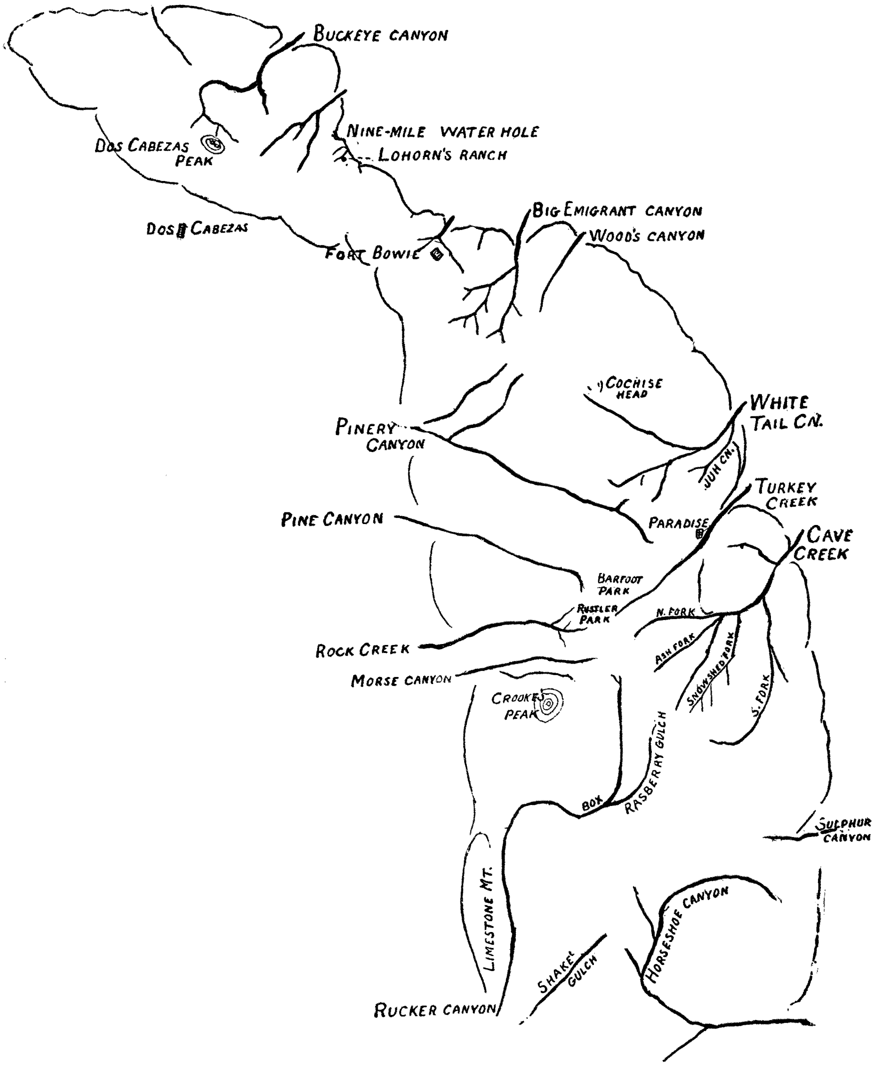


Fig. 1.—Map showing positions of the canyons in the Chiricahua range.

We have herein given an account of the present status of the molluscan fauna as full as circumstances permitted. In many of the canyons we have endeavored to locate the individual snail colonies with sufficient detail to insure their recognition by subsequent observers, so that their further evolution may be followed. Large areas still remain to be explored, and neither author has had time to fully study the material collected.

The first record of mollusks from the Chiricahuas was made by Dr. R. E. C. Stearns, who in 1890 describes specimens of *Holospira arizonensis*,[3] collected by Mr. Vernon Bailey for the U. S. Department of Agriculture at Dos Cabezas, in the western foothills of the Dos Cabezas Mountains. In 1895 Dr. W. H. Dall described *Polygyra chiricahuana* and subsequently (1897) he reported *Pyramidula striatella*, *Thysanophora ingersolli* and *Zonitoides arborea*,[4] all from Fly's Park in the central Chiricahuas, collected by Dr. Fisher. No other species were known from the range prior to the first visit by Mr. Ferriss in February, 1904. Numerous new species were found during this brief visit, notwithstanding the unfavorable season. In November, 1906, both of us collected in the range, exploring the principal canyons from Buckeye in the north to Cave Creek and the parks about its head. In November, 1907, Messrs. Ferriss and L. E. Daniels spent two weeks in the Chiricahuas, and in 1908, from September 20 to November 15, Ferriss continued the work of exploring the southern canyons.

I. Conditions Determining the Isolation of Snail Colonies.

The faunas of the several mountain ranges of southern Arizona are separated one from another by the intervening nearly level mesa, where snails are absolutely wanting and cannot exist. This is due not alone to their greater aridity, higher temperature and xerophytic flora, but chiefly we believe to the absence of rocks, in the interstices of which snails might burrow below the dry surface to depths where a certain amount of moisture is retained. The mesa forms a barrier as impassable to land snails as an equal expanse of sea; and can be surmounted only by minute forms light enough to be transported by the wind. During the existence of the present conditions, which probably were initiated in the Pliocene, the larger snails of each range have been absolutely isolated.

Owing to the general north and south trend of the ranges, the main canyons run eastward or westward, thus exposing a very hot slope with little vegetation northward and a more shaded slope on the south side, having more vegetation, but deeply interrupted by side canyons and ravines. These conditions may be illustrated by the map of White Tail Canyon (p. 75). It will be noticed thereon that on the southern side of the canyon the collecting stations are nearly all on *northwestern* slopes, none on northeastern. The latter are barren, and except near the top of the ridge form impassable barriers to mollusks. In the more arid portion of the range, snails are rarely found, often wholly wanting, on the slopes with mainly southern exposure. These conditions of exposure determine the limits of snail colonies, absolutely inhibiting migrations of much extent, though the anastomosing heads of adjacent canyons sometimes supply favorable slopes.

---

[3] *Proc. U. S. Nat. Museum*, XIII, 1890.

[4] *Proc. U. S. Nat. Museum*, XVIII, 1895, and XIX, 1897.

The isolation of snail colonies is further favored by the habits of most of the Helices, which live deep in rocky talus or slides. They probably crawl about in the open only on rare occasions, and are wholly incapable of crossing slopes where shelter is lacking. We have never found living Helices on the surface in the Chiricahua Mountains, and with the exception of *Oreohelix chiricahuana,* living individuals were always found well buried in the rocks. Of some species, not even dead shells have been found on the surface. Some of these races apparently live and die under the surface.

The progressive growth of the canyons by the deepening of lateral ravines and formation of new ones constantly accentuates the isolation of colonies by forming new slopes, of which one in each case is likely to be arid and therefore a barrier to the spread of snails. Moreover, the removal by erosion of stratified rocks, especially limestone, exposes ridges of granitic or eruptive rocks, in which snails are generally scarce, and some genera never present. Since the period of isolation of the several ranges, there has therefore been progressive isolation of colonies within each range.

II. INFLUENCE OF ENVIRONMENT ON THE SHELL.

Relation of Climate to Shell-texture.—Notwithstanding the aridity of the climate, the Chiricanuan snails show none of the characteristics which some recent authors have considered to be the direct reactions to the desert environment. With the exception of *Oreohelix chiricahuana,* none of the species are conspicuously earthy, and none differ markedly in sculpture from snails of more humid districts.

Rude, irregular sculpture and opaque chalky substance characterize land snails which live *exposed to the sun.* In such places their active life and periods of growth are certainly limited to dewy nights and times of rain,[5] whether they live in a reasonably humid region, as *Cerion* on the coast of Cuba, or in an arid region, as some Oreohelices of the Rocky Mountains. Pulmonate land snails which pass their lives hidden from the sun or shaded by dense foliage, do not have notably chalky shells, even in Arizona where a great part of the year is dry. We regard the opacity and cretaceous texture of exposed snails as in no way due to the direct action of climatic factors,[6] but as a protective adaptation to excessive sunlight, which would readily penetrate thin shells, or those composed largely of conchiolin.[7]

Oreohelix chiricahuana and in some cases *Holospira* are the only Chiricahuan snails which live on or close to the surface, uncovered or only partially protected; these are also the only snails which have the shell notably chalky and opaque. The snails of the dryest (Dos Cabezas) part of the range are not "desert snails" in appearance. They live where little light or none can penetrate.

Relation of Exposure to Size.—The size of individual snails (excepting the heliophilous group discussed above) is almost wholly a function of the exposure. *Snails living on northern or northwestern exposures are invariably larger than those from southern or eastern exposures,* regardless of elevation,[8] unless other conditions are conspicuously unfavorable. This is apparently due to the more abundant cryptogamic or other plant food, the growth of which is favored by the more humid slopes,[9] as well as the greater duration of humid growing periods. As would naturally be expected, the difference in size of the snails is more marked in rather dry or semi-arid regions than in those abundantly watered and shaded. Our measurements of *Sonorella* support the observations already published on other species.

In some cases the divergence has proceeded so far that diversity of size becomes an important specific character, as in the case of *Sonorella leucura* and *micra*, living on opposite sides of White Tail

---

[5] Additions to the shell are made only when the animal is active, during humid periods, and thus exposed neither to arid winds or alkaline dust. Growth of the shell does not proceed when the snail is retracted and at rest, but only when it is in full activity, with the mantle fully produced.

[6] As claimed by Dr. W. H. Dall, *Proc. A. N. S. Phila.*, 1896, pp. 411, etc.

[7] A long list of conspicuously opaque, chalky snails which æstivate in the full glare of the sun could be given. We may mention *Leucochroa*, *Cerion incanum maritimum*, etc., *Bulimulus alternatus*, *Oreohelix strigosa huachucana*. Allied species which live in more shaded places tend to lose their opacity; *cf. Oreohelix barbata* and *O. clappi*.

[8] At least within limits of two or three thousand feet.

[9] We have already given data in support of this fact in *Proc. A. N. S. Phila.*, 1906, pp. 552–555, and in other places.

Canyon. Where snails are gathered from one limited region and those from various colonies are not kept separate, the measurements of such series when plotted may form conspicuously bimodal curves, due to the mixture of shells from different exposures. Such results are entirely worthless in the study of the relations of organism to environment.

We have made no exhaustive series of measurements to ascertain whether the height of the spire varies with elevation of the station, but such observations as we have made indicate that it does not. In the helices there is rather wide individual variation in height of spire at all levels indifferently.[10]

Influence of the Character of the Rock.—Land snails are notoriously more abundant on limestone than where the country rock is igneous. They are also usually heavier, the shell-walls thicker, though this is not the case with all species. The individuals apparently reach at least as large a size where lime is scarce as where it is abundant, if other conditions (exposure and humidity) are about equal. In several cases the largest individuals occurred under granitic rock, as in the case of *Sonorella bicipitis* at Nine-mile water-hole.

Enemies.—Field mice are apparently the chief enemies of the larger snails of the Chiricahuas. We often found unmistakable evidences of their destructive activity. The crevices of rock-piles which harbor most of the snails are often accessible to mice; and no protective device seems to have arisen effective against the latter. *Oreohelix barbata*, which from the dirt on its hairy coat is rather hard to see, we noticed on several occasions had been cruelly preyed upon by mice. We can offer observations upon predacious insects.

III. Factors in the Formation of Races and Species.

The several modifications of the shells which we have noted above as correlated to some extent with external factors are only in minor part such features as serve to signalize species.[11] Thus in *Sonorella* the species are based mainly upon characters of the genitalia. In *Ashmunella* upon the teeth of the aperture and the shape of the last whorl. In *Holospira* the shape of the spire and its sculpture are the chief differential features. Moreover, in many cases, allied but distinct species live under conditions which so far as we can see are identical. The subterranean Sonorellas, such as *bicipitis*, *optata*, *bowiensis* and *leucura* inhabit slopes having similar exposure, vegetation, elevation, and rock cover, yet they differ characteristically in genitalia. At the same time, one style of genital organs seems to be as fit as another. Nearly all of the Holospiras live in very similar places. The local differences in the stations of the typical colonies of *Oreohelix chiricahuana*, *obsoleta* and *percarinata* are apparently less than the differences between the several stations of colonies of *chiricahuana*. If the conditions seem practically identical on parallel slopes of different canyons, it seems hopeless to search for differential conditions among several rock-piles or taluses along one canyon side, having the same exposure, composed of the same rocks, separated perhaps only by arid gulleys or barren earth slopes; yet such taluses often harbor perceptibly different colonies of the same species.

---

[10] Bellini's recent claim that on Capri the snails from greater elevations have higher spires, due to diminished atmospheric pressure, seems to us fantastic in the extreme.

[11] In White Tail Canyon, however, *Sonorella micra* and *Ashmunella lepiderma* differ from their fellows on the more shaded side of the canyon by features mainly traceable to the different exposure and rock.

The facts developed in our Arizona work lead us to doubt the potency of environment as a direct agent in effecting specific differentiation, or at least to assign such factors a wholly subsidiary role. The facts seem explicable only on the hypothesis of variations existing or arising in the constitution of the egg, leading to modifications of the adult organism which for the greater part are indifferent as affecting the well-being of the race. Such adaptation as exists would apparently be due to selection. The isolation of small colonies in these mountains must favor the survival of what are currently called mutations occurring therein. The occasional mingling of neighboring colonies in which diverse variations have arisen seems to have led to such heterogeneous colonies as we have described in *Holospira*.[12]

We have no definite evidence to offer bearing upon the amplitude of individual variations or "mutations," yet we may again mention the fact that in many species nearly every colony has its minor peculiarities—peculiarities far below the grade usually called "specific," yet appreciable to the trained eye.[13] It may be inferred from this fact that the amplitude of "mutations" is ordinarily not great.

IV. Distribution of Chiricahuan Mollusks.

The snail fauna of the Chiricahuas consists of 51 species, falling into two main categories:

---

[12] We believe this to be the explanation of the diversity of colonies in the polychromatic arboreal snails such as *Partula* and *Liguus*, in which some colonies of a given species are homogeneous, while others are heterogeneous, snails of several definite color-patterns being the offspring of a single mother.

[13] Only the application of careful biometric methods can fully or definitely bring out these minute differences.

1. *Species peculiar to the range:* all forms of the genera *Sonorella, Oreohelix, Ashmunella* and *Holospira,* 21 species with 14 subspecies. These are the larger snails of the fauna, without exception larger and heavier than any of the snails ranging also outside of the Chiricahuas. The members of this group of forms have probably been isolated in these mountains since the beginning of the present climatic cycle. They are too heavy to be transported across the mesa by wind, and the probability that they would be carried by birds or other accidental means is so remote as to be negligible. All of them were apparently derived from not more than six ancestral specific stocks; the species of *Ashmunella* and *Holospira* forming homogeneous groups probably of common ancestry, while in *Sonorella* and *Oreohelix* the species fall into two groups.

2. *Species having a distribution outside of the range:* all of them smaller than the preceding and many minute.

(*a*) Alpine forms, mainly living above 7,500 feet, and elsewhere found only in the Canadian zone of the Rocky Mountains northward. Those found also in the Huachuca range are indicated by the letter H.

Thysanophora ingersolli meridionalis.
Vitrina alaskana, H.
Euconulus fulvus alaskensis, H.
Pyramidula cronkhitei, H.
Vertigo columbiana utahensis.
" *modesta parietalis,* H.
" *coloradoensis basidens.*

(*b*) Transition zone forms chiefly having an almost continental distribution in that zone, also ranging into higher and lower zones.

Zonitoides arborea, about 8,000 feet, H.
Cochlicopa lubrica, 6,000–8,000 feet, H.
Pupilla hebes, 7,500–8,000 feet, H.
Vertigo milium, 8,000 feet, H.
Succinea avara, about 6,500 feet, H.

The species of groups (*a*) and (*b*) are forms which from their wide distribution must be of considerable antiquity, all probably having existed practically unchanged since before the initiation of present climatic conditions in Arizona. The absence of any form of the *Oreohelix strigosa* group is remarkable, on account of the very wide distribution of this Transition zone type in the Rocky Mountains.

(*c*) Upper Sonoran species, most of them widely distributed in the Southwest, some ranging into the Lower Sonoran. Those found also in the Huachuca and Florida ranges marked with the letters H. and F.

Thysanophora hornii,[14] H. F.
Agriolimax hemphilli ashmuni,[15] H.
Zonitoides milium meridionalis, H.
“ *minuscula alachuana,* H.
Vitrea indentata umbilicata, H.
Helicodiscus eigenmanni arizonensis, H.
Radiodiscus millecostatus,[15] H.
Punctum californicum.[15]
Vallonia perspectiva,[14] H. F.

Bifidaria pellucida hordeacella.
“ *quadridentata,*[15] H.
“ *pilsbryana,* H. F.
“ *perversa.*[14]
“ *ashmuni,*[14] H. F.
“ *cochisensis,*[14] H.
“ *dalliana.*[14]
“ *tuba.*[14]
Pisidium abditum huachucanum[15], H.

With the single exception of *Agriolimax,* all of these are very small or minute snails, certainly capable of being carried long distances by cyclonic winds, and it is likely that their wide distribution may be attributed in part to such means, though it is not improbable that a considerable number of the forms may have existed before the isolation of the Arizona ranges.

Twenty-two of the thirty species of groups 2 (*a, b, c*) have been found in the Huachuca range.[16] These are indicated in the list above by the letter H. Four species, marked F in the list, occur in the far poorer fauna of the Florida Mountains.

FAUNAL ZONES represented in the Chiricahuas are the Canadian, the Transition, and the Upper Sonoran. Zones dependent upon elevation are less distinctly marked in mollusks than in plants or vertebrates, local exposure and suitable conditions of moisture controlling the distribution of species to such an extent that the elevation zones are extremely irregular. It appears, however, that the Canadian zone forms are strictly confined to the high "parks" and peaks. The characteristic Transition zone species are also for the most part high on the range, as are also five species which, from their distribution elsewhere, are considered to be Upper Sonoran. Seven of the eighteen Upper Sonoran species have been found only below 7,000 feet, while six have a general range.

In the group of species peculiar to the Chiricahua range, and which must apparently be considered Upper Sonoran, many of the forms are very local in distribution and belong to the middle and lower zones of the range. Those having a wider distribution often have a great vertical range, as the following examples:

---

[14] Found only low, below 7,000 feet.

[15] As yet found only at about 8,000 feet or above, but none of them known from much further north than the Chiricahua range.

[16] *Proc. A. N. S. Phila.* for 1909, pp. 498–516.

Sonorella virilis, 6,000 to 9,000 feet.
Oreohelix clappi, 6,000 to over 8,000 feet.
Ashmunella chiricahuana, 6,000 to 8,500 feet.
" *angulata*, 6,000 to over 8,000 feet.

Sonorella virilis leucura, *S. micra*, *Ashmunella proxima*, *A. fissidens* and their subspecies, and *Holospira*, seem, in their several areas, to range from low to as high as suitable cover and slope-exposure are found. *Ashmunella esuritor*, *metamorphosa* and *duplicidens* belong to the higher levels (where the flora is very different), while *A. ferrissi* has not been found over 6,500 feet, if so high as that.

In general, the specially Canadian and Transition species seem to be more sharply limited in their range downward than the Upper Sonoran forms are in their extension upward. We attribute this as much to the difference in plant life as to any more direct climatic conditions.

The Lower Sonoran zone, in this area, has no land molluscan fauna, but *Physa* and *Lymnæa* occur in the *cienega* east of the Chiricahuas.

V. Systematic Descriptions of Species.

Family **HELICIDÆ**.

This family comprises four genera in Arizona: *Sonorella* Pils., *Oreohelix* Pils., *Ashmunella* Pils. and Ckll., and *Thysanophora* Strebel. *Ashmunella* is confined to a comparatively small area in the southeastern corner of the territory; but the other genera extend to the northern border, but they are only locally distributed, and some or all may be absent over areas of hundreds of square miles. *Ashmunella* and *Sonorella* are Upper Sonoran genera. *Oreohelix* belongs to the Transition zone, often extending into the Canadian (where it is usually dwarfed), and sometimes into the Upper Sonoran zone, where it is mainly represented by special species.

The genera *Ashmunella* and *Sonorella* are curiously diverse in modes of racial differentiation. In *Ashmunella* the *shell* has been most modified. In series of allied forms from successive canyons of a single range the shells will show much greater divergence than the soft parts. This is well illustrated by the Huachucan series, which, with conspicuous differences among the shells, shows hardly any in the soft parts. In *Sonorella*, on the other hand, the shells from a series of successive canyons may show barely perceptible differences, but the genitalia have been so modified in detail that the species are instantly recognizable from these organs. The conditions in *Sonorella* form a strong argument against modification by the action of environment. The differentiation affects internal organs concerned solely in the act of reproduction, and only in the most remote manner connected with parts directly acted upon by external factors.

Genus **SONORELLA** Pilsbry.

Sonorella is the most characteristic Helicid snail of the mountains of southern New Mexico and Arizona. It is more widely distributed than either *Ashmunella* or *Oreohelix,* inhabiting mountains too arid to support either of the other genera, such as the Peloncillo, Dos Cabezas and Rincon ranges. In the Grand Canyon of the Colorado we dug them from the cruelly sharp rock-slides of the pre-Cambrian zone, in deep, sunless canyons where no other snails penetrate; and they exist equally on the plateau at the rim, 5,000 feet above the sea.

This tolerance of untoward conditions is doubtless due in part to their deep digging habit. *Sonorella* is usually found well down in the rocky talus or slide, in the layer against the earth, where a certain degree of moisture remains. In some places *Ashmunella* accompanies *Sonorella* in the same slides. This is especially the case in the more verdant and humid canyons, such as Cave Creek in the Chiricahuas, where *Sonorella, Ashmunella* and *Oreohelix clappi* may be found together.

Oreohelix (except *O. clappi* and *O. barbata*) lives on the surface, on or under the top stones, or around dead mescal, bear grass or yuccas. While apparently fitted to live in exposed and extremely arid places, yet in southern Arizona *Oreohelix* certainly does not inhabit the more arid ranges where *Sonorella* exists.

Oreohelix and *Ashmunella* may sometimes be collected in copious quantity, but *Sonorella* is almost always rare. In the Dos Cabezas range a half dozen living adults would be a good day's bag for any collector, and in dry weather, at least, this would mean very hard work. In less arid localities the snails are less scarce; but as a general rule to collect living Sonorellas successfully is the most strenuous physical labor, occasionally enlivened by danger of broken limbs from falling rocks or caving in of holes, in slides of heavy rock. Strong gloves are necessary in "quarrying" for *Sonorella.* In spite of strained muscles, bruises and bleeding fingers, the fascination of *Sonorella* hunting is irresistible. The game gains in value from the hardihood brought out in the chase, and it is only after one has forgotten the labor that he can part with a single specimen of the rarer species.

Chiricahuan Sonorellas belong to two very diverse groups distinguished as follows:

Key to Chiricahuan Species of Sonorella.

a.—Penis comparatively short, very much less than the diameter of the shell, and about ¼ to ½ the length of spermatheca and its duct (Group of *S. hachitana*).

b.—Penis-papilla annulate, the free end more or less pointed; epiphallus less than half the diameter of shell; whorls 4¾ to 5¼.

c.—Flagellum wanting or vestigeal; diameter of shell 15.5 to 25 mm. .... *S. optata.*

c^1.—Flagellum distinct but minute; diameter of shell 18 to 26 mm. .... *S. bicipitis.*

b^1.—Penis-papilla plain, cylindric with obtuse end; epiphallus about half the diam. of shell; penis larger; whorls about 4½.

c.—Umbilicus contained about 5½ times in diameter of the shell, which is depressed, 15 to 18 mm. in diameter. *S. bowiensis.*

c^1.—Umbilicus contained about 10 times in diameter of shell, which is subglobose, 13.5 to 20 mm. in diameter. *S. binneyi.*

a^1.—Penis very large, its length exceeding the diameter of the shell, and not differing much from the length of spermatheca and duct; penis-papilla and vagina very long (Group of *S. virilis*).

b.—Shell moderately solid, larger.

c.—Diameter of shell 16 to 21 mm. .... *S. virilis.*

c^1.—Diameter of shell 18 to 25 mm.; more depressed. *S. v. leucura.*

b^1.—Shell thin, smaller, diameter 12 to 15 mm. .... *S. micra.*

Group of Sonorella hachitana.

Sonorella bicipitis n. sp. Pl. I, figs. 1–5.

Shell of the group of *S. hachitana*, the umbilicus about one-seventh the total diameter, and one-third covered by the dilated columellar lip; brown, fading to white around the umbilicus, encircled above the periphery with a dark chestnut band bordered above and below with white bands of about the same width; the brown band visible on about two whorls of the spire, the upper white band visible also on the penultimate whorl. Whorls 4¾ to 5, rather slowly increasing at first, the penultimate and last whorls rapidly widening. Surface nearly smooth to the eye, glossy. Embryonic shell consisting of 1½ whorls. The first half whorl has distinct radial ripples; the next whorl has close, fine wrinkles in the direction of growth-lines, and interrupted by delicate, spirally descending threads. The third whorl shows some very sparse punctation. Later whorls are marked with fine growth-ripples, and usually show, under a strong lens, some excessively faint spiral lines above the periphery. The last whorl descends moderately in front, and is well rounded on periphery and base, as usual. The aperture is large, oblique, rounded, nearly as high as wide. Peristome thin, narrowly expanded outwardly, the basal margin a trifle reflexed, columellar margin dilated in a curved triangular plate over about one-third of the umbilicus. Alt. 14, diam. 23 mm.; aperture, alt. 12, diam. 13 mm.

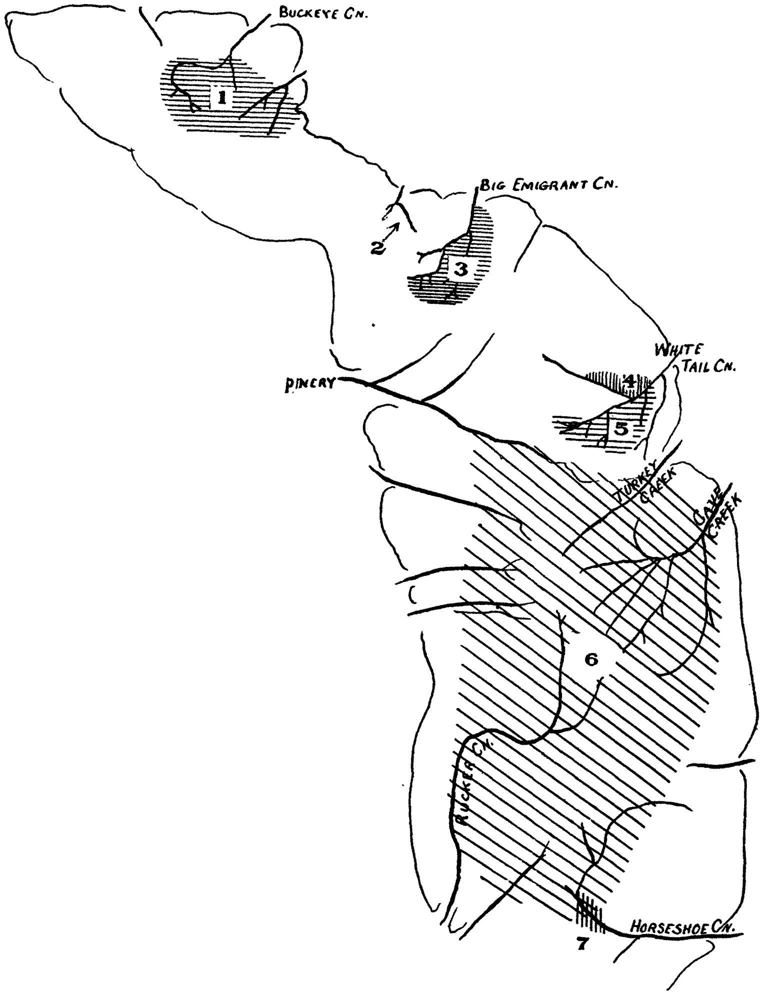


Fig. 2.—Distribution of *Sonorella* in the Chiricahua Mountains: 1, *S. bicipitis*; 2, *S. bowiensis* (at point of the arrow); 3, *S. optata*; 4, *S. micra*; 5, *S. virilis leucura*; 6, *S. virilis*; 7, *S. binneyi*. Large areas between 1 and 2 and between 3 and 4 are unexplored.

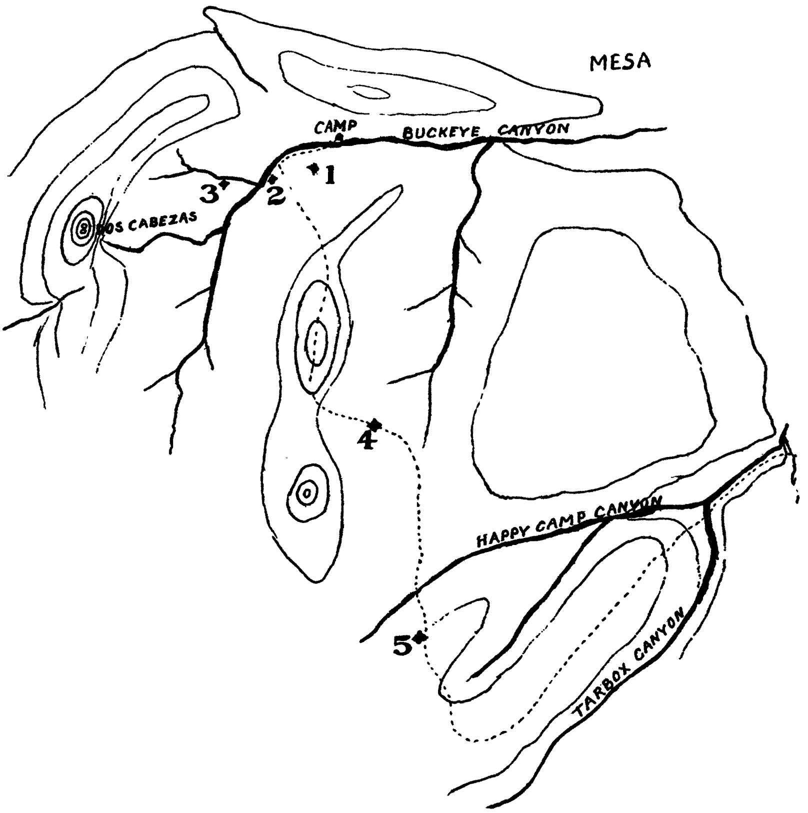


Fig. 3.—Principal collecting stations in the northern canyons of the Dos Cabezas range.

Genitalia, Pl. III, figs. 1, 2, 4, 7. Penis of moderate length, somewhat less than one-third the length of spermatheca and duct, with a long retractor muscle; the penis-papilla (*pp.*) cylindric, annulated distally, with conic tip. Epiphallus somewhat shorter than penis; flagellum 0.6 or 0.7 mm. long. Vagina generally not much longer than the penis. Sole (in alcohol) ochre or dirty white, uniform or with slightly darker sides. Back gray, the flanks and tail very pale.

Jaw with 6 to 8 ribs, grouped in the median half. Radula with 26,12,1,12,26 to 27,13,1,13,27 teeth, centrals and laterals without ectocones; some of the marginals with both cusps bifid.

Type No. 94,328 A. N. S. P., from Buckeye Canyon, Dos Cabezas range of the Chiricahua Mountains, at Station 1, fig. 3.

It ranges throughout Buckeye and Happy Camp Canyons, and at

Nine-mile Water-hole, living deep under stones and rocks. Buckeye Canyon is the first from the northern end of the range. Its upper branches drain the eastern flanks of Dos Cabezas Peak. At the time of our visit in November there was water at intervals in the stony bed of the canyon as far down as our camp, near the reduction plant of the Buckeye gold mine. Tarbox and Happy Camp Canyons unite into a wide valley about a mile from the mesa. The mouth of this valley is half closed by a great reef of light gray granite rocks which forms a conspicuous landmark from the mesa. The country rock of these canyons is mainly metamorphic, but in part granitic.

This species has the same apical sculpture as *S. bowiensis* and *S. optima*. It differs from *optima* in the shape of the penis-papilla, the presence of a flagellum, the shorter inner cusp of the marginal teeth, the larger aperture and narrower umbilicus. *S. hachitana* from the Big Hachet Mountains has a decidedly smaller aperture. In shell characters *S. bicipitis* stands nearest *S. huachucana*, but the apical sculpture of the latter is much less distinct, without the oblique threads on the last embryonic whorl which are characteristic of *S. bicipitis* and related forms. This species is represented by 43 adult shells, of which 17 were taken alive, and many young ones. The colonies are widely separated[17] and small; living shells are rare, and their collection involves the removal of much rock. The physical conditions are very similar in all the stations in Buckeye and Happy Camp Canyons. All the stations are on steep well-drained slopes facing northward, the earth very dry (in November), even under a couple of feet of rock, and scantily protected by low scrubby oak brush. At Nine-mile Water-hole the conditions are quite different as noted below.

In the type locality, Station 1 (pl. I, figs. 1, 2, 3, and pl. III, fig. 7), we took 7 living adult and 6 young specimens measuring as follows:

Alt.	14.8	14.2	14	13	13	13	12.2 mm.
Diam.	24	23.3	23	22	22	21	20.2 mm.

This station is high on the steep south side of the canyon.

In a lot of 23 from Station 3 (No. 94,326), 7 are adult living shells, measuring:

---

[17] This must be understood in a comparative sense, as indicating that many apparently suitable situations examined were found barren. Doubtless a longer search would show that a large number of small colonies exist. We worked two days in Buckeye and several hours in Nine-mile.

Alt	12.8	12.2	12.2	12.7	12	11.8	11.5 mm.
Diam	21	21	20.5	20	19.2	19	18.5 mm.

Ten adults from the slopes around the head of the southeastern branch of Buckeye Canyon, Station 4, vary from 18.7 to 22 mm. diameter (No. 94,325).

Thirteen adults were taken at Station 5, near the head of Happy Camp Canyon, only one alive.

Alt	13	13	12.6	12.3	12.3	11	11.7 mm.
Diam	22.3	21	20.7	20	20.2	20	19 mm.

Alt	11.7	11.8	12	11.2	11	10.5 mm.
Diam	19.2	19.2	19	19.2	19	18 mm.

At Nine-mile Water-hole we obtained a single living adult snail and 8 young (No. 99,324). These, with a specimen taken by Mr. Ferriss in 1905, indicate a large race at this place, with a slightly larger umbilicus than the types, and more closely approaching lip-ends (pl. I figs. 4, 5). The soft anatomy, sculpture and color are like typical *S. bicipitis*. Whorls barely 5. Two adults measure:

Alt	15	15 mm.
Diam	26	25.5 "
Aperture alt	13	13 "
" diam	14	14.5 "

The genitalia are figured pl. III, fig. 2.

Nine-mile Water-hole is a shallow amphitheatre open eastward to the mesa, its slopes covered with great weathered boulders of coarse-grained light gray granite, among which ferns grow luxuriantly. A tiny stream trickles among the rocks, collecting into a stagnant pool at the base. A man can make his way in the interstices between and under the rocks, in some places, but as very few of them are movable, it is almost impossible to obtain the shells.

Specimens were dissected from Stations 1, 3, 4, 5 and from Nine-mile Water-hole. All have a distinct sheath at the base of the penis, attached also to the epiphallus and partially enveloping the latter throughout a part of its length. This sheath varies from about one-third the length of the penis in the type lot, to about a half in that from Nine-mile. The penis-papilla in transverse section (fig. 7, *pp.*) shows a group of minute ducts, but there seems to be a single terminal orifice. The vagina is longer in the types than in other lots examined.

Measurements of genitalia in millimeters.

Locality.	Penis.	Penis-papilla.	Epiphallus and flagellum.	Flagellum.	Vagina.	Spermatheca and duct.	Penis retractor.	Diameter of shell.	Museum No.
Station 1, fig. 7	8	4.5	6.5	0.6	14.5	29	long	23	94,328
Station 3, fig. 1	9.5	6	8	0.7	9.5	......	"	21	94,326
Station 4, fig. 4	7	6	7	0.6	....	......	......	19	94,325
Nine-mile, fig. 2	9	4.3	7	0.6	10	29	14	26	94,324

In the alcoholic specimen from Nine-mile, the sole is tripartite by faint longitudinal impressed lines, with a median groove due to partial folding of the foot. There are transverse lines as shown in pl. III, figs. 3 and 6. The granulation above is fine and pebble-like as usual in *Sonorella*. The œsophagus is short, expanding into a large crop, on which the loose and open salivary glands lie. The liver is reddish purple. The buccal retractor and left ocular retractor are united in their posterior third, the tail and right ocular retractors being free to their common insertion. The lung is like that of *Sonorella optata.*

In the specimens from Stations 3, 4 and 5, no longitudinal impressed lines could be traced on the sole.

The jaw varies a good deal; a specimen from the type lot has six wide ribs. From Station 4 and Nine-mile the jaw has eight narrow ribs.

All of the radulæ examined agree in having decidedly fewer teeth in a transverse row than *S. hachitana flora* or *S. optata.*

Sonorella optata n. sp. Pl. I, figs. 6–12, 17–19.

The shell is umbilicate, umbilicus slightly less than one-seventh the diameter, similar to *S. hachitana.* Pale brown, fading to whitish around the umbilicus, encircled by a rather wide dark chestnut band above the periphery, bordered above and below with paler, whitish bands. The spire is low conic. Whorls 5¼, slowly increasing to the last, which is much wider, and descends deeply in front. The embryonic shell consists of 1½ whorls. The first half whorl has radial wrinkles, and begins in a smooth tip; then a small areolate area follows, after which there are curved, forwardly descending delicate threads reaching the suture below, but weak or obsolete on the summit of the whorl, which is irregularly roughened; there are also some forwardly ascending threads in places. The first neanic whorl has sculpture of slight growth ripples and an indistinct roughening or punctation. Subsequent whorls are lightly marked with growth-lines only. The aperture is very oblique, subcircular; peristome thin, a little expanded, narrowly reflexed below, the columellar margin dilated. Alt. 15, diam. 24 mm.; alt. aperture 11.7, width 13 mm.

Penis small, usually shorter than the vagina, and less than one-third as long as the spermatheca and duct. Epiphallus short, the *flagellum apparently absent* or reduced to a very minute adnate cœcum (pl. IV, figs. 1, 2, 3, 4, 5, 7). Radula with 35, 1, 35 (summit of Cross J Mt.) to 38, 1, 38 teeth, about 14 laterals, an ectocone appearing on the 11th to 13th. The entocone is bifid on the outer 15 to 18 marginals, and the ectocone occasionally so on some teeth, though generally simple. Six radulæ from 5 stations examined. The jaw has 5 ribs in two, 6 and 7 in two other examples. The crops and œsophagus as far as the stomach are conspicuously sulcate or corrugated longitudinally.

Type locality, head of Big Emigrant Canyon at Station 1, on a steep slope shaded by pinyons, under large stones (limestone). The species occurs in numerous colonies throughout Big Emigrant Canyon, except on slopes with southern exposure. See map on p. 121.

This handsome species, like others of the *hachitana* group, is ill-characterized as far as the shell is concerned, but the genitalia are characteristic by the small penis and absence of a free flagellum. In the Chiricahua Mountains it is related to *S. bicipitis* of the Dos Cabezas range, but in that the penis is well developed and the flagellum, though small, seems to be invariably present. In all of the numerous examples opened the crop and intestine to the stomach are deeply furrowed longitudinally, a condition observed in no other *Sonorella*. To what extent this corrugation may be due to the state of the specimens is uncertain. It happened that by some unaccountable oversight all of the Big Emigrant Sonorellas were cooked and pulled without drowning, and then were preserved in alcohol too strong to give the best results.

All of the following colonies but one are on limestone.

Type locality, Station 1. Thirty adult specimens were taken, ten of them alive. They measure as follows:

Diam. in mm	26	25.3	25	25	25	25	24.8	24.8
Alt. in mm	15.3	15	16.3	14.9	14.2	14.2	15	15

Diam. in mm	24.3	24.3	24.3	24.2	24.2	24	24
Alt. in mm	15	14.6	14.3	15	14	16	15.2

Diam. in mm	24 (three)	24	24	24 (three)	23.3	23
Alt. in mm	15	14.5	14.3	14	14	14

Diam. in mm	23	23	23	23	22.8
Alt. in mm	14	13.5	13.1	13	13.5

The total variation in diameter in this colony is 3.2 mm. The variation in altitude is comparatively greater, owing to the varying degree of elevation of the spire. 70 per cent. of the lot are from 24 to 25 mm. in diameter. Figures 6–9 were drawn from specimens of the type lot from this Station.

Station 4. Cleft in the rocky summit of hill at fork of Big Emigrant Canyon, facing mouth of canyon (pl. I, fig. 10). Ten specimens, two alive, measure:

Diam. in mm	26	25.5	25.5	25	25	25	24	23.7	23.3	23.3
Alt. in mm	15	16	14.7	16	15	15	14.7	13.3	13	13

They differ from the type lot in having the aperture barely perceptibly larger, umbilicus smaller. In a specimen of the type lot 25 mm. in diam. the aperture measures 11.4 x 13.1 mm. In one of the same diameter from Station 4 it is 12 x 13.4 mm.

Spirally striate forms.—The shells from Stations 2, 3, 5, 6—Big Emigrant Mountain and Cross J Mountain—usually show numerous spiral striæ on the upper surface of the last whorl, but this character is variable; in some shells of each lot no spiral striæ can be made out.

Station 2. Close to the creek in the middle branch of Big Emigrant Canyon, under stones. Three dead shells measuring 23.5, 22.3 and 21.8 mm., and similar to those from Big Emigrant Mountain. This place is probably about 1,000 feet lower than the type locality.

Station 3. Big Emigrant Mountain. This name is given to a mountain about four miles above the fork of Big Emigrant Canyon on the left side of the east branch. November 11 and 12 it was visited. On the side toward the canyon, under a rocky bluff, under stones among scrub oaks (*Quercus hypoleuca*?), in a situation resembling that of *Sonorella bowiensis*, numerous specimens of a small form were taken, almost all dead shells. Sixty-five adults taken measure in diameter as follows:

Diam. in mm	20.5	20	19.5	19.3	19	18.8	18.5	18.3
No. of shells	1	1	4	1	6	4	7	6

Diam. in mm	18	17.8	17.5	17.3	17	16.5	16	15.5
No. of shells	7	4	4	5	7	3	4	1

The shells are in the average more depressed than typical *S. optata*. The largest measures, alt. 10.5, diam. 20.5, aperture 9.2 x 11.2 mm. Another, alt. 10.5, diam. 18.5, aperture 8.3 x 9.9 mm. There are about 4½ whorls, the last with some spiral lines on the upper surface, sometimes very faint.

From the west side of Big Emigrant Mountain (pl. I, figs. 11, 12, 18, 19) a lot of 32 living adults was taken, of almost equally small size (No. 94,320).

Diam. in mm	21.4	20.5	20	19.75	19.5	19	18.7	18.3
No. of shells	2	2	4	6	7	9	1	1

The degree of elevation is somewhat variable. In one specimen (pl. I, fig. 19) the dark band is wanting. This is the only case of the kind among our Chiricahua Sonorellas.

Another lot of 35 living adult shells from another place on Big Emigrant Mountain average larger.

Diam. in mm	23	22.5	22	21.5	21	20.5	20	19.8	19
No. of shells	1	1	1	7	8	7	8	1	1

Station 6, high in the valley north of Cross J Mountain, 42 adult shells, most of them "dead," measure:

Diam. in mm	22.8	22.5	22.3	22	21.8	21.5	21.3	21	20.5	20
No. of shells	2	3	2	6	3	4	3	10	4	5

Most shells show spiral lines, as in those from Big Emigrant Mountain. The specimens were taken in the area indicated in the sketch on p. 87, but similar dead shells were seen throughout the valley, on both sides of the ravine. The rock of this valley is limestone.

Eastward from this valley (Station 6) a rugged ridge of coarse crumbling granitic rock runs towards the mouth of the canyon (see map). Five dead shells found on the outer side of the crest of this ridge are like those from the valley, but smaller, diam. 18.5 to 20.5 mm.

Station 5. Among rocks at and near the north side of the summit of Cross J Mountain. The rock here is angular, friable and cherty. The shells, 29 adults, mostly "dead," resemble the larger colony from Big Emigrant Mountain, most of them showing fine spiral lines. The elevation is estimated at 8,000 feet. See sketch on p. 87.

Diam. in mm	23	22.8	22.2	22	21.8	21.5
No. of shells	2	1	1	5	4	1

Diam. in mm	21.2	20.8	20.5	20.2	20	19.8
No. of shells	5	1	4	1	1	3

Small form of S. optata (pl.I, fig. 17). Some very small specimens were taken near the head of Big Emigrant Canyon south of Station 1, the exact spot not noted. Two living ones measure, alt. 9.8, diam. 16 mm., and alt. 9.2, diam. 16 mm.

A bleached shell was found at Station 2; alt. 11, diam. 18 mm.

Soft anatomy of S. optata. Specimens from four colonies have been dissected. In the type lot from Station 1, the sole is pale, unicolored. In some other lots the narrow side areas are a shade darker. The genitalia (pl. IV, fig. 1–4, 7) are characterized by the very small penis and absence of a flagellum, verified in several examples opened. The lung (fig. 4, right fig.) has venation much as I have described for *S. ashmuni*. The secondary ureter is open throughout, being defined by a thread-like ridge only. Length of lung 26, of kidney 14, of pericardium 5 mm. The foregut and crop are deeply sulcate longitudinally.

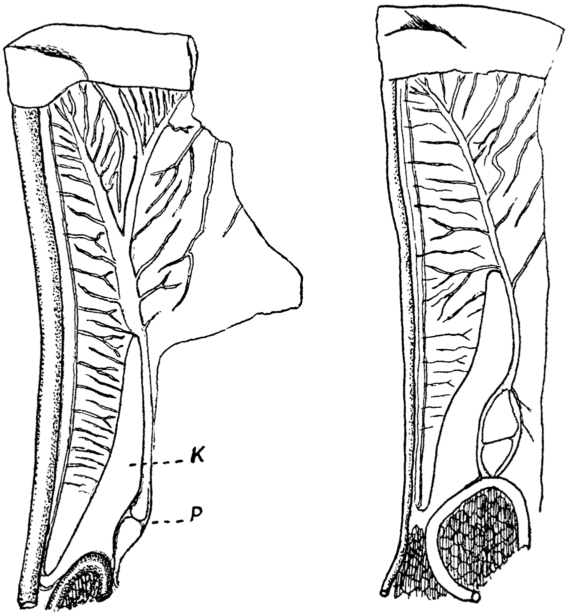


Fig. 4.—Pallial region of *Sonorella optata*, two individuals. K, kidney; P, pericardium.

In specimens from the cleft in Big Emigrant Canyon (No. 94,321), the penis is rather larger (pl. IV, fig. 4). It has a thin, rather short basal sheath and long retractor. The penis-papilla is slender, cylindric, weakly annulate, with obtusely conic end. There is an excessively short cœcum representing the flagellum, not free from the integument and hardly visible except by transmitted light. The crop and foregut are longitudinally sulcate. Salivary glands long, united over the upper surface of the crop.

The form from north side of Big Emigrant Mountain (Station 3, No. 94,322) is similar. Genitalia (pl. IV, fig, 1) with long penis-papilla, its end long-conic. Flagellum a barely perceptible bud bound in the integument. Lung with venation typical or (in one of several examined) the pulmonary vein has a large branch on the cardiac side, where the venation is otherwise very faint. Length of lung 27, of kidney 14, of pericardium 4.5 mm. (fig. 4, left fig.). The crop and foregut are deeply sulcate longitudinally. No. 94,320, from west side of Big Emigrant Mountain are similar. As usual in this species, the penis-papilla has a somewhat glans-like end (fig. 2).

No. 94,323, from summit of Cross J Mountain, has the sole pale in the middle, shading into gray at the sides. No flagellum. Foregut corrugated. The penis-papilla is obtuse, but the specimen is not quite mature (pl. IV, fig. 7). A half-grown shell has very minute genitalia (pl. IV, fig. 5) with a very short papilla.

Measurements of genitalia of S. optata in mm.

Locality	Penis.	Penis-papilla.	Epiphallus.	Flagellum.	Vagina.	Spermatheca and duct.	Penis retractor.	Diameter of shell.	Museum No.
Station 1, fig. 3	5	3	3.3	0	8	....	10+	25	94,319
Station 4, fig. 4	7	4	3.5	vestigeal	8	26	7.5	25.5	94,321
Station 3, fig. 1	4.5	4	5	"	6	24	....	18.5	94,322
Near Station 3, fig. 2	5	2.6	5	"	5	20	....	19.5	94,320
Station 5, fig. 7	4.6	2.6	2.75	0	7	....	long	20	94,323

Sonorella bowiensis Pils. Pl. I, figs. 13–16.

Sonorella hachitana bowiensis Pils., Proc. A. N. S. Phila., 1905, p. 260, pl. XVIII, figs. 29–32 (shell); pl. XX, figs. 10, 11 (genitalia); pl. XXIII, fig. 22 (jaw).

Forty-one living and twenty-eight dead adult specimens were taken at the type locality in 1906. It is a very pretty shell, quite constant in all its characters.

The shell is somewhat transparent, pale corneous-brown becoming lighter almost corneous-whitish near the umbilicus. There are usually one or two obliquely radial whitish streaks on the last whorl. The chestnut band above the periphery is about one millimeter wide, is visible on 2½ to 3 whorls, and has a very faint paler border below, hardly visible; no noticeable pale border above the band. Whorls

4½, rather slowly widening to the last, which is nearly double the width of the preceding, and well rounded peripherally. The embryonic shell consists of 1½ whorls; the apex is smoothish; then a radially wrinkled area follows to the end of the first half whorl; the next whorl has forwardly descending delicate threads on its outer or peripheral half, the inner half being irregularly, shallowly pitted and roughened. The succeeding neanic whorls are lightly striate obliquely and very slightly, minutely roughened. The last whorl descends rather deeply in front. The umbilicus is contained about 5½ times in the diameter of the shell. The aperture is very oblique, peristome expanded, the ends strongly converging, the columellar end dilated, slightly impinging on the umbilicus.

Measurements of seven specimens were given in our former paper, with diameters of 15 to 17.8 mm. Sixty-nine adults taken in 1906 have the following diameters:

Diam. in mm	15	15.5	15.8	16	16.2	16.3	16.5	16.7	16.8	17	17.8	18
No. of shells	4	3	2	22	2	7	5	4	6	12	1	1

About 84 per cent. are from 16 to 17 mm. in diameter, and the total range in diameter is only 3 mm.[18] Otherwise variation is seen only to a very slight extent in the width and intensity of the band and in the degree of deflection at the aperture.

Type locality.—Quartzite Hill, back of Dixon's place, about a mile south of old Fort Bowie. It has been found nowhere else.

The locality was wrongly given as "Bowie" in our former paper. Bowie is a station on the S. P. Railway about 15 miles from Fort Bowie, and on the mesa where no snails live. Fort Bowie is now deserted, and only the roofless adobe buildings and the cemetery remain.

Sonorella bowiensis was found only in one colony very limited in extent but prolific in individuals. This colony—the only place where we have ever found *Sonorella* in abundance—is in a small thicket of long-leaved scrub-oaks with some underbrush of service berries (*Amelanchier* sp.) under a low cliff, somewhat more than half way to the summit of Quartzite Hill, back of Dixon's place, shown at (1) in the photographic reproduction below. The snails were under small stones and dead leaves. The abundant shelter and food and favorable northeastern slope apparently led to an unusual multiplication of individuals, but no environmental factor seems to account for their very small size. We searched the neighboring Bull Hill thoroughly for *Sonorella*, but without success. Probably a more extended exploration would result in finding other colonies in the Fort Bowie Valley. Bowie Mountain and Helen's Doom should be examined.

---

[18] The concentration around the diameters 16 and 17 mm. is partly due to the fact that all shells more than 15.8 and less than 16.2 were counted as 16, and similarly with 17, giving a wider range than with any intermediate measurements.

The single locality of *S. bowiensis* lies between the ranges of *S. bicipitis* and *S. optata*.

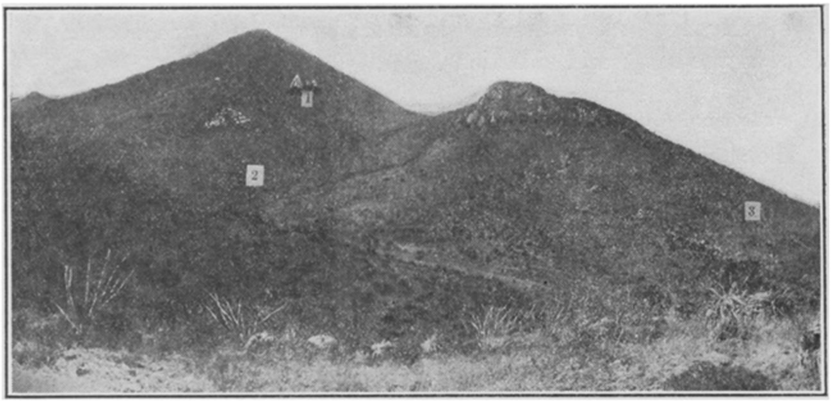


Fig. 5.—Quartzite Peak and Bull Hill, from the ridge on east side of the creek, looking across Dixon's place, showing type localities of *Sonorella bowiensis* (1) and *Holospira cionella* (2).

S. bowiensis differs from *S. bicipitis* by the rounded end of the penis-papilla and the actually and comparatively longer penis, over half the length of spermatheca and duct, though the shell is smaller. The shell differs by its smaller size and the faintness or absence of white bands bordering the chestnut zone.

The living animal is slate color on head and back, sides of foot pale blue, borders of the foot orange; liver brown. In alcohol the back is slate, sides, tail and sole whitish. The sole has slightly darker lateral areas marked off with faint grooves. The crop is long and smooth.

I have figured the genitalia of a specimen (pl. IV, fig. 6) for comparison with that previously published. The well-developed penis has a long basal sheath, the lower part of the penis itself being quite slender. The papilla is cylindric, somewhat more than one-third the length of the penis, with a blunt, rounded end. The penis retractor is long. The organs measure as follows: length of penis 12 mm.; of penis-papilla 4.4 mm.; epiphallus and flagellum 12; flagellum 0.6; vagina 10; spermatheca and duct 21.5 mm. The atrium is extremely short.

In its genitalia this species resembles *S. binneyi* from the southern end of the range, and to a less extent *S. rowelli.* The embryonic sculpture is like that of *S. bicipitis,* but the spirally protractive threads are more numerous and closer.

S. binneyi differs from *S. bowiensis* by the very much smaller penis, only half the length of that of *S. bowiensis* in a larger shell; by the different shape of the papilla, and the absence or very minute size of the flagellum. The shell also is invariably larger than *S. bowiensis,* even in the most arid situations.

Sonorella binneyi n. sp. Pl. II, figs. 13–18.

The shell is depressed globose, narrowly umbilicate, quite thin but moderately strong; pale brown with some whitish oblique streaks, and fading to opaque white around the umbilicus, encircled with a narrow chestnut band at the shoulder, narrowly showing above the suture on the penultimate whorl. Surface slightly shining, marked with fine, rather sharp growth-striæ. Whorls 4½, convex, the first minutely roughened but without distinct pattern of sculpture. The last whorl is very wide (viewed from above), inflated, rounded peripherally, very convex beneath. It descends in front. The aperture is very large, strongly oblique, elliptical, the ends of the lip converging. Peristome thin, very slightly expanded throughout, dilated at the columellar insertion.

Alt. 13, diam. 20; width of aperture 12.8, oblique alt. 11 mm.; width of umbilicus 1.7 mm.

Alt. 11.5, diam. 18 mm.

Alt. 10.5, diam. 16 mm.

Horseshoe (Mo) Canyon, the types from Station 1, two miles up the Canyon. Also found near the red box of Horseshoe Canyon.

The genitalia (pl. III, fig. 5). The penis is somewhat longer than the vagina. It contracts into a narrow neck at the base, and contains a cylindric papilla, obtuse at the free end, and from one-sixth to about one-third the length of the penis. Epiphallus not very unlike the penis in length. Flagellum as usual in the genus. The vagina is short. Spermatheca oval, on a long duct. Two specimens of No. 97,414 measure:

Length of penis	8	11.5	mm.
" " epiphallus	9	8	"
" " papilla	3	2.5	"
" " flagellum	1	....	"
" " vagina	6	....	"
" " spermatheca and duct	22	....	"

The jaw has five ribs. The pericardium is about half as long as the kidney.

In its soft anatomy, this species resembles *S. bowiensis* Pils. and also *S. rowelli* (Newc.), but differs from the latter by having a distinct flagellum. The shell is more like *S. rowelli*, but differs from both species by its more inflated contour and very large aperture. In conchological characters the species is, for a *Sonorella*, very distinct, and unlike other known Chiricahuan snails.

The smallest specimen seen measures, alt. 8, diam. 13.5 mm. This species is named in memory of William G. Binney.

Group of Sonorella virilis.

These forms are distinguished from all other Helices known to us by the enormous length of the penis and its papilla. *Sonorella rinconensis*, which has an equally long penis, but a comparatively short papilla, is apparently the most nearly related species. All other known Sonorellas have the penis short or of moderate length. All known species of this group are Chiricahuan. The sculpture of the embryonic shell resembles that of the group of *S. hachitana*, but usually the pattern is very indistinct.

Sonorella virilis Pils. Pl. II, figs. 1-6.

> *S. virilis* Pils., Proc. A. N. S. Phila., 1905, p. 266, with var. *circumstriata*, p. 267.

This species was described from a single shell which so far as we can learn was probably taken in Rucker Canyon. The variety *circumstriata* was described from the talus at the foot of Reed's Mountain, about a half mile below Reed's place, Station 11 in Cave Creek. The series now available shows that this variety is scarcely distinct enough for recognition, or at least that it is difficult to decide upon some specimens. Figures 1, 2, 3 represent specimens from Station 11, at the foot of Reed's Mountain, Cave Creek Canyon. Figs. 4, 5 are from about two miles up the south fork of Cave Creek. All of these are of the form *circumstriata.*

Fig. 6 is from Spring branch near Rucker Camp, head of Rucker Canyon. This shell, and others from the head of Rucker, has a broad conspicuous white border above the brown band, a narrower one below it; the brown band is broader than in Cave Creek shells. The spire, viewed from above, is narrower, the last whorl therefore wider.

Specimens from further down Rucker have much less conspicuous white borders along the band, and are like the type of *virilis.*

This species also occurs in Morse Canyon, tne foot of Bonito Canyon, and Shake Gulch, and in Horseshoe Canyon near the Red Box.

In the Cave Creek Canyon Valley it may be found almost anywhere suitable rock cover exists, though there are large areas without it, where the slope is slight or with southern exposure. Rock "slides" or northern exposures with abundant rock are its chief haunts. It was taken at Stations 3, 4, 5, 11, 12, 13, 14, also near the branch leading toward Paradise, in the ravines west of Reed's Mountain, and various places throughout the South Fork as far as explored—about two miles up. None were taken on the great ridge where Stations 6 and 7 are situated, or on the ridge marked 10. The valley south of the stream from the falls has not been explored. The Sonorellas were also found in a great rock slide (trachyte?) on the south side of a peak near the sawmill, in Barfoot Park, Station 1, and in the head of the adjacent canyon running westward. See map on p. 107.

S. virilis (*circumstriata*) was found also in Paradise Canyon about two miles below Paradise, and in Pine Canyon.

Variation.—There is the usual variation in degree of elevation of the spire, and slight variation in ground color of the shell, in all of the lots examined, but various colonies differ in size, as may be seen by the table of measurements of specimens from four places. This size variation is not in the least correlated with elevation, but is invariably connected with the exposure to the sun. Thus it will be noted that at Stations 1 and 12 the mode is at 18 mm. diameter, the total range from 16 to 20 mm. Both of these stations are on *sunny southern slopes,* Station 1 being Barfoot Park at an elevation of over 8,000 feet, while Station 12 is only about 100 feet above the bottom of Cave

Creek, at an elevation of about 6,000 feet. These small specimens contrast with those from Stations 13, *from shaded slopes,* where the mode is at 20 to 20.5 mm., and the range from 17.75 to 21 mm. Large shells occur at Station 11, at the shaded and humid base of Ried's Mountain, about 6,000 feet elevation, and at the head of Pine Canyon, at about 8,000 feet, also in a comparatively humid and well-shaded situation. The shells from other places, while too few to be worth tabulating, or to give reliable curves, support the above conclusions as far as they go.

Diameter in mm.	Sta. 1.	Sta. 4.	Sta. 11.	Sta. 12.	Sta. 13	Head Pine Canyon.
16...........	....	....	....	1	....	....
16.25......	1	....	....	....	....	....
16.5........	....	....	....	....	....	....
16.75......	....	....	....	....	....	....
17...........	2	....	....	1	....	....
17.25......	3	....	....	1	....	....
17.5........	....	....	....	1	....	....
17.75......	4	1	....	3	1	....
18...........	5	3	....	5	....	....
18.25......	1	....	....	1	....	....
18.5........	....	2	....	....	1	1
18.75......	....	....	....	1	....	1
19...........	4	1	....	2	2	1
19.25......	....	....	....	1	....	....
19.5........	....	2	....	....	....	....
19.75......	....	....	....	1	4	1
20...........	2	....	5	....	5	1
20.25......	....	....	....	....	1	....
20.5........	....	....	5	....	....	1
20.75......	....	....	....	....	1	....
21...........	....	....	1	....	1	2
22...........	....	....	....	....	....	1
Total......	22	9	11	18	16	9

The sole, in alcoholic examples, is yellowish in the central field, the lateral areas grayish, grooves rather indistinct. The back is blackish, sides pale.

Specimens from numerous lots were dissected, genitalia of two being figured (pl. V. fig. 6, No. 94,335 from Station 13, South Fork of Cave Creek, and fig. 4, No. 94,332, from Station 11, Cave Creek). The penis is longer than in the original type specimen, but in about the same proportion to the length of the vagina, which varies considerably. This difference in length is perhaps due to the different modes of preservation. The basal sheath of the penis and its retractor are both quite short. The arcuate shape of the penis is due to its position near the periphery of the last whorl when the animal is retracted.

Measurements of the genitalia in millimeters.

Species.	Penis.	Penis-papilla	Epiphallus.	Flagellum.	Vagina.	Spermatheca and duct.	Penis retractor.	Diameter of shell.	Museum No.
1. *S. virilis*..................	29	24	18	....	23	....	6.5	19	94,335
2. "	30.5	29	19	0.7	26.5	31	6	20	94,332
3. "	34	29	22	1	16	24	....	19.5	79,622
4. "	30	....	22	....	19.5	....	....	22	97,409
5. "	27	....	....	....	....	....	....	22	97,409
6. "	28	....	....	....	....	....	....	19	97,408
7. *S. v. leucura*..........	31	28	15	0.6	17	26	....	21	94,331
8. "	28.5	25	21	0.6	21	....	....	23	99,682
9. "	25	21.2	19	0.6	15	25	....	19	99,681

The specimens measured are from the following localities:

1. South Fork of Cave Creek.
2. Foot of Reed's Mountain, Cave Creek.
3. Rucker Canyon (?). Original type of *S. virilis*.
4, 5. Head of Rucker Canyon.
6. Rucker Canyon at mouth of Raspberry Gulch.
7. White Tail Canyon, Station 4.
8. White Tail Canyon, Station 14.
9. White Tail Canyon, Station 00.

Sonorella virilis leucura subsp. nov. Pl. II, figs. 7–9.

The shell is decidedly *more depressed* than *S. virilis* or *S. v.* "*circumstriata*," though the spire is about equally convex; the umbilicus is wider; the aperture is smaller, and the ground-color is paler, subopaque, whitish, tinted more or less with brown, nearly white on each side of the dark band, and pale around the umbilicus.

Embryonic and neanic stages.—There are 1¾ embryonic whorls. The depressed tip is smoothish, followed by only a few radial wrinkles; following embryonic whorl is roughened with low granules lengthened in a radial direction, or short, irregularly waved or vermiculate radial wrinkles; over these there is a pattern of grains in regular squares at first, but soon forming protractive rows, the grains becoming indistinct. On the first post-nepionic whorl the fine striæ are more or less interrupted or minutely indented in places. The post-nepionic whorls as far as *the fourth whorl are clothed with very short deciduous hairs,* so delicate that the slightest attempt to clean the shell removes them, and they probably never persist in the adult stage. All immature specimens taken by us in November, from diam. 10 mm. on, have *a strong callous rib within the lip-edge.*

Adult stage.—There are 4½ whorls in small, 4¾ in large individuals of the type lot, slowly increasing at first, the last whorl seen from above about twice as wide as the penultimate. The lip is blunt with rusty edge, but not thickened within. The outer margin is slightly expanded, the basal a trifle more so; parietal callus rather thick at the edge, straight. The umbilicus contained about 5.2 times in the total diameter. Alt. 11.8, diam. 23.5 mm.; aperture 10 x 11.3 mm.

Distribution: Southern side of White Tail Canyon, Chiricahua Mountains, Stations 1, 2, 3, 4, 5, 9, 12, 14. Type locality, Station No. 14. Also in Jhu Canyon. See map, fig. 6, p. 75.

This is the only *Sonorella* on the southern side of White Tail Canyon, living on steep slopes varying from northeast to north or northwest. It occurs (in November) rather deep under rocks, and excepting on the more arid slopes and ridges, colonies may be found where suitable shelter occurs throughout the length of the canyon, generally rather high on the slopes, but in at least one case only about 20 feet above the bed of the canyon. The more favorable slopes, such as those Stations 5, 14, 15 are situated on, are wooded with pinyon below, oak and a few long-leaf pine above. The ridges and slopes with southern or eastern exposure are barren or nearly so. The rock is limestone, mostly with covering of earth and fine stone, and there are no rock slides. Stations 1, 2, 4, and 9 are decidedly more arid and barren than 5 and 14, Station 5 being near the bottom of a deep narrow ravine, densely wooded, while Station 14 is on a steep shady northern slope. The lots taken show that the shells respond to more favorable conditions by reaching a larger size, as seen in the table of measurements.

The shells from Station 5 have the spire somewhat more depressed than any other lot. Those from near Jim Artels' old camp, near head of White Tail not far from Station 1, are the smallest.

The table following shows the shells from high on the ridge (Stations 1 and 4) to be in the main smaller than those from the mid-slope; but this ridge becomes very dry above, with less shade, while the slope lower down is well shaded on northwest exposures (caused by the lateral washes and ravines, running northward), the northeast exposures being for the most part barren. The size of individuals in the colonies collected appear, therefore, to be related to the amount of shade and moisture.

Measurements of 152 shells from six stations follow:

Diameter in mm.	Near Sta. 1.	Sta. 4.	Sta. 2.	Sta. 5.	Sta. 9.	Sta. 14.
18	1	....	....	....	....	....
18.25	2	....	....	....	....	....
18.5	2	....	....	....	....	....
18.75	9	....	....	....	....	....
19	4	....	....	....	....	....
19.25	2	....	....	....	....	....
19.5	1	....	....	....	....	....
19.75	3	1	....	....	1	....
20	1	1	....	....	2	....
20.25	....	....	....	....	....	1
20.5	....	....	....	....	....	....
20.75	....	2	1	....	3	....
21	....	2	....	....	10	7
21.25	....	....	2	....	3	5
21.5	....	1	....	1	2	3
21.75	....	4	2	....	....	9
22	....	2	....	2	1	11
22.25	....	....	....	2	....	4
22.5	....	....	....	2	....	3
22.75	....	1	....	....	....	5
23	....	1	1	4	....	6
23.25	....	....	....	3	....	....
23.5	....	....	....	....	....	1
23.75	....	....	....	3	....	....
24	....	....	2	5	....	1
24.25	....	....	....	2	....	....
24.5	....	....	....	....	....	....
24.75	....	....	....	1	....	....
25	....	....	....	....	....	....
25.25	....	....	....	1	....	....
No. of shells...	25	15	8	26	22	56

Soft anatomy.—Several specimens were dissected, from three stations, 14, 4 and from near Station 1. The genitalia do not differ from these organs in *S. virilis circumstriata.* Measurements may be found on p. 72. An example from Station 4 (No. 94,331) is illustrated (pl. V, fig. 5). It shows the penis kinked in a way unusual in the species.

The sole is tripartite in color, the central area, half the total width, being pale isabelline, the side areas gray. The foot is gray above, darkest on the back; top of the tail of a dirty yellow tint.

Sonorella micra n. sp. Pl. II, figs. 10–12.

The shell is small, thin, the umbilicus contained about five times in the total diameter; pale brownish-corneous, a little paler around the umbilicus, and with scarcely perceptible pale borders above and below the dark chestnut band above the periphery; only slightly glossy. Spire very low. The embryonic shell consists of 1½ convex whorls; after the smooth apex, there are a few arcuate radial ripples; and the

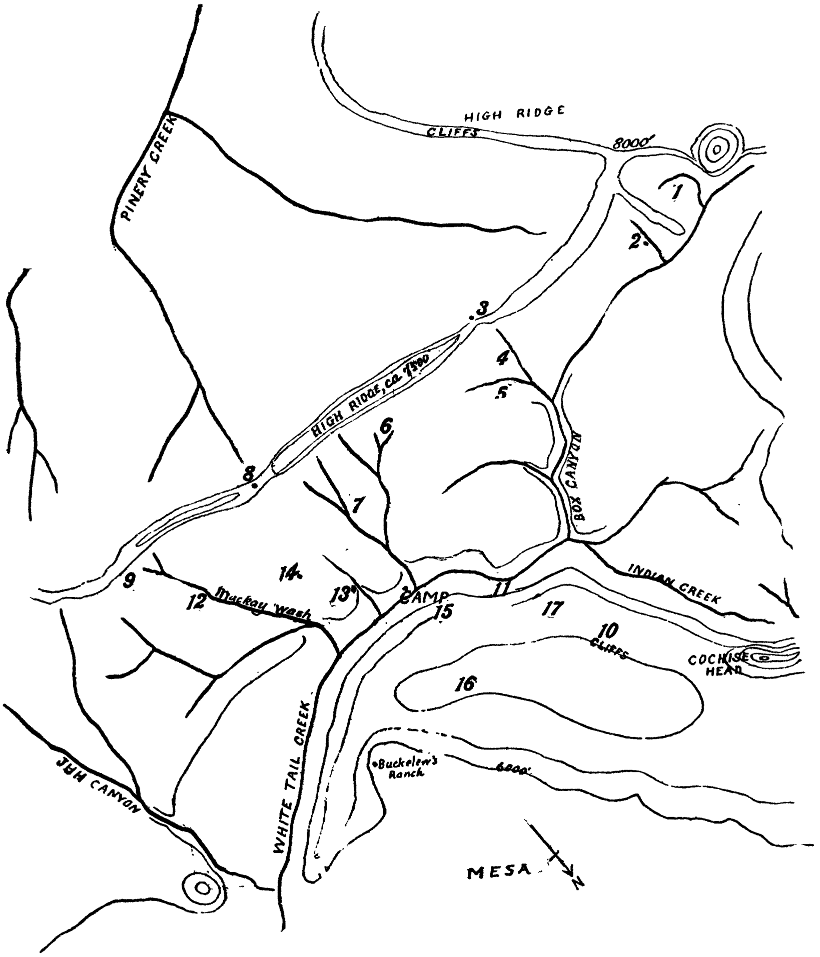


Fig. 6.—Collecting stations in White Tail Canyon.

rest of the embryonic shell has irregular rugosities or asperities, short, but longest in a radial direction; over these there are granules arranged as in *S. v. leucura.* When absolutely unworn they bear delicate hairs in young shells. The following post-embryonic whorls are delicately striate, and as far as the beginning of the fourth whorl, fresh and uncleaned young shells have close, short and very delicate hairs. The last whorl has delicate growth-lines, but no trace of spiral striæ; it is rounded at the periphery and descends a little in front. The aperture is oblique, rounded. The peristome is thin, outer margin scarcely noticeably expanded, basal margin somewhat more so; columellar margin rather broadly dilated and brought forward. The parietal callus is short, thin and transparent.

Alt. 7.2, diam. 14.5 mm.; aperture 7.5 mm. wide, 7 high. Whorls 4¼.

Distribution: North side of White Tail Canyon, in slides of igneous rock (rhyolite), at Stations 10, 11, 15, 16, 17. Type locality, Station 10. See map on p. 75.

This is the smallest *Sonorella* yet known from the Chiricahuas. It is allied to *S. virilis* by the genitalia and the indistinct sculpture pattern on the embryonic whorls, but differs by its diminutive size, thin shell, comparatively narrower umbilicus and the absence of distinct white borders along the brown band.

S. micra occupies the north side of White Tail Canyon to the exclusion of *S. virilis leucura,* which lives on the opposite or south side. It lives in "slides" of angular, dark purplish-gray rock (rhyolite), together with *Ashmunella lepiderma,* and can be found only deep in the rocks, where they rest on the earth below. The slopes are mainly toward the south and west, hence exposed to the direct sun, rarely shaded to any extent by the small trees. The snails are found from the bottom of the canyon (Station 11) to perhaps 6,800 feet (Station 16), where they occur over the crest of the ridge, in an extensive slide sloping northward. The type locality, Station 10, is below the great cliffs along Indian Creek. The lower stations are easily accessible, but the higher call for arduous climbing and, from the nature of their haunts, the work of quarrying the snails out is severe. We secured but few living specimens, but many dead shells, more or less fresh, show the species to be remarkably constant. Besides a slight variation in elevation of the spire, no variation in form is noticeable. Measurements of two lots follow:

Diam. in mm	12.75	13	13.25	13.5	13.75	14	14.25
Station 10	1	0	0	1	2	7	4
Station 17	0	1	0	4	4	10	4

Diam. in mm	14.5	14.75	15	15.25
Station 10	4	7	7	1
Station 17	1	3	2	0

On the southern side of the canyon we found a few dead specimens among limestone rocks about 20 feet above the bed of the canyon, below the junction of Indian Creek. They agree fully with those from the north side of the canyon.

S. micra occurs associated with *Ashmunella lepiderma* in the same rock slides. Both are modified in the same manner, the shell differing from allied species in being smaller, thinner, dull, with a greater or less development of cuticular processes. The reduced size compared with the species on the opposite side of the canyon is without much doubt due to the sun-scorched exposure. We have not found that living on igneous rock has any tendency to dwarf Sonorellas, though the tenuity of the shell may fairly be attributed to that influence.

The animal in alcohol is pale grayish, darker on the back. Sole with the usual pale central area and slightly darker side areas, not defined by lines.

The genitalia of a drowned specimen in good condition from Station 10 is drawn in pl. V, figs. 1, 2. Unfortunately the penis was exserted in all of this lot. Except in being smaller and *more slender*, the organs resemble closely those of *S. virilis.* The penis in this figure is shown partially everted, the long papilla (*pp.*) projecting. In fig. 2 the epiphallus is shown partially uncoiled. The flagellum is well developed for a *Sonorella.* Pl. V, fig. 3, represents the organs of another specimen, from Station 17, with the penis normally retracted. The end of the penis-papilla is shown in outline

Measurements in millimeters of the genitalia of two specimens follow:

Penis.	Papilla.	Epiphallus.	Flagellum.	Vagina.	Spermatheca and duct.	Penis retractor.	Diameter of shell.	Museum No. of shell.
17	14	10.5	0.6	8	16	8+	14.8	94,334
14	11	13	0.5	9	17	4.5	14	94,330

Genus **OREOHELIX** Pilsbry.

The Chiricahua Mountains harbor two groups of *Oreohelix* with a well-developed nearly black, green or yellow cuticle, so far unknown elsewhere. In one of these, the *barbata* group, the shell is bi-convex, with whorls of small calibre, a wide umbilical cavity and numerous spiral wreaths of cuticular fringes. The other, the *O. clappi* group, has an orbicular shell usually banded, with large tubular whorls and a smaller, rapidly diminishing umbilicus. In one of the forms both the cuticle and the shell beneath possess well-defined spirals similar to the cuticular fringes of *O. barbata;* but here the likeness ends. In general appearance these Chiricahuan forms have little resemblance to groups of *Oreohelix* in the Huachucas or elsewhere. The *clappi* group further differs from the *O. strigosa* group in possessing radially costulate apical whorls.

Snails of both of these groups live immured in the shaded rocks of the mountain "slides," composed of broken rock or spawls tumbled down from the peaks above. *O. clappi* lives from 5,000 to 7,000 feet, and *O. barbata* from 7,000 to 10,000 feet above the sea. The dead shells are seldom found upon the surface. *Oreohelix chiricahuana*, in the same mountain range, requires but little covering, and is found in dry situations, often with but a single leaf or a small spawl for protection. It agrees with the Oreohelices of other regions in having a very thin cuticle, often wanting. Dead agavas and yuccas furnish a home for these, the Holospiras and *Succinea avara;* but *O. barbata* and *O. clappi*, the Ashmunellas and Sonorellas require an atmosphere with more moisture, and dwell from one to two feet below the surface. He who finds must dig.

All Chiricahuan Oreohelices are confined to that range, and none of them are closely related to species found elsewhere. All are conspicuously variable in each colony and in different colonies, nearly every one of which shows a degree of racial differentiation, so that one acquainted with these shells, even as imperfectly known at present, could locate himself if lost in the Chiricahuas by digging for Oreohelices!

No adequate discussion of these shells can be entered into without more and better illustrations than are possible to us at this time, and long series of measurements. We have merely indicated briefly the salient features of each colony.

The Oreohelix clappi series.

The group of local races which for taxonomic purposes is considered to compose the species *O. clappi* comprises about a dozen colonies, scattered over the range for a distance of about 44 miles. The relationships of the snails of these colonies may be expressed diagramatically thus:

Emigrans—Onion Creek—Reed's Mt.—type———Cataracta
|
Horseshoe—Shake Gulch—Rucker Box

The forms toward the left in this diagram are successively more roughly sculptured, toward the right they are smoother. The type happened to be of intermediate character, and near the central point of the range of the species. The upper line forms a variation-series extending from Big Emigrant Canyon (*emigrans*) to the Falls of

Cave Creek (*cataracta*). The lower line is a similar but independent chain from the southern canyons, a considerable distance from the nearest of the more northern group.

From Big Emigrant Canyon to Shake Gulch the Stations mentioned above run in a general direction from northwest to southeast. From the *emigrans* station to Onion Creek station is about 16 miles; thence to Cave Creek, 4; to Cave Creek Falls (var. *cataracta*), 2; to Rucker Box, 12; to Shake Gulch, 12. Total, 44 miles as the crow flies; but it is 55 by trail.

One peculiarity runs throughout the entire *clappi* series: they are hard to catch. Except at Onion Creek they were grouped in small families and the families did not seem to be upon speaking terms. They were clannish and confined their travels to one particular rock slide. In only two instances was the same form found in two slides of rock, though the rocks were well explored for miles around. At Onion Creek they were plentiful; about 100 were collected there in an hour.

Oreohelix clappi emigrans n. subsp.

This shell is similar in outline to *O. clappi*, but more sharply angular at the periphery, or even carinate in front. Cuticle thicker, rough, usually persistent, dark olive brown in color, lusterless, not banded, coated and caked with a deposit of humus. The sculpture after the embryonic shell consists of oblique, uneven, rather sharp striæ, and on the last whorl some coarse wrinkles. The striæ are sharper than in *O. clappi* and close together up to the last whorl; on the base they are *thread-like, crimped and waved* at the intersections of four or five circular rows of short cuticular appendages, which are usually retained only on the latter part of the base. In immature shells the thread-like striæ are surmounted by delicate cuticular laminæ, more or less felted together by the adhering dirt. The aperture is rounded-

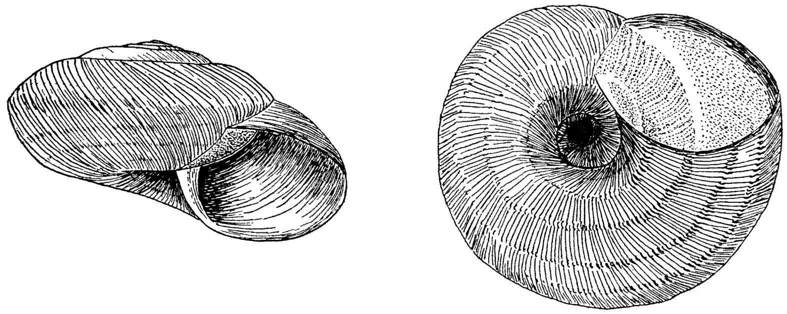


Fig. 7.—*Oreohelix clappi emigrans.*

piriform, the lip margins converging, thickened at the ends and connected by a thin film across the parietal wall. Interior bluish white. Alt. 9, diam. 16 mm., whorls 5.

Big Emigrant Mountain, on the south side of Big Emigrant Canyon, at about 7,000 feet elevation, taken in some numbers in a shattered column of stone and also in a rock slide. This place is about 20 miles across the mountains northwest from the Cave Creek Station for *O. clappi.*

O. c. emigrans is the dirtiest of the group—in its natural state as black as the soil. It is well distinguished by the sculpture, and would be considered a separate species in a less variable group than *Oreohelix.*

Oreohelix clappi Ferriss.

Oreohelix clappi Ferriss, Nautilus, XVIII, p. 53 (Sept., 1904). Pilsbry, Proc. A. N. S. Phila., 1905, p. 285, pl. 25, figs. 54–56 (shell); pl. 19, fig. 8 (genitalia); pl. 22, fig. 4 (teeth); pl. 23, fig. 26 (jaw).

The shell is moderately depressed, with tubular whorls and deep suture, the altitude about two-thirds the diameter and about equally convex above and below the peripheral angle. The umbilicus at the opening is about one-sixth the diameter and contracts rapidly, only the penultimate whorl visible. Calcareous layer of the shell is brownish white under a thin greenish-yellow cuticle with some darker oblique streaks, which become in mature shells darker and crowded near the aperture. Many possess two indistinct transparent olive spiral bands, one above, the other just below the periphery. In old individuals the cuticle remains only in ragged shreds. The first 1½ embryonic whorls are strongly ribbed radially; these riblets are regular and narrower than their intervals. At the end of the embryonic shell the whorl slightly widens abruptly, with sculpture of rather coarse irregular obliquely radial wrinkles and traces of fine spiral striæ. The last whorl has unequal, irregularly spaced oblique wrinkles, *weak and low at the base,* which is densely covered with minute wavy spiral striæ, obsolete in old individuals. Where the wrinkles pass over the angular periphery they are sometimes somewhat more emphatic, a little pinched up. There are *no spaced circular threads or cuticular fringes on the base.* Whorls 4¾, convex, the last double the width of the preceding. Base very convex. The aperture is very shortly ovate or nearly circular, very oblique, and about one-half the diameter of the shell. The ends of the lips converge. The short parietal callus is a thin transparent film, or in old shells the peristome is continuous, as a raised parietal ledge. Old age is expressed by a deeper descent of the last whorl and closer approach of the lip margins, as usual in the genus *Oreohelix.*

Seven fully adult shells of the original lot measure:

Alt.	10,	diam.	15	mm.
"	9,	"	14.3	"
"	8.7,	"	14.5	"
"	9,	"	14.3	"
"	8.5,	"	14.3	"
"	9.5,	"	14.9	"
"	8.9,	"	14	"

This exact form has been found only at the type locality on the south side of Cave Creek below the place marked Camp on the map, p. 107, where it was taken in 1904, deeply imbedded in rotten shale near the water's edge. About 30 specimens.

In its native state *O. clappi* is covered with humus, perhaps attached by mucus. But few specimens were found except in the type Station. Its habit of burying deeply in the soil probably accounts for its rarity.

Elsewhere in Cave Creek Canyon a slightly different form (see below) was found in 1906 at Stations 9, 11, 12, near 13, 14 and in the ravine west of Reed's Mountain. These stations are all near the bottom of the canyon. It was not found higher up. Here it occurs with *Sonorella, Ashmunella chiricahuana, A. ferrissi* and *A. angulata.*

2. Lower Cave Creek Form.—The shells taken in 1906 at Stations 9, 11, 12 and near 13, 14, Cave Creek, are slightly more angular at the periphery than the types, and the growth-wrinkles bear short cuticular lamellæ where they pass over the peripheral angle in fresh and unrubbed individuals not fully mature. Often, but not always, there are three circular rows of inconspicuous granules at wide, equal intervals on the base, a weak or vanishing development of the basal sculpture of *O. c. emigrans.* The two brown bands (one at the outer third of the upper surface of the last whorl, the other below and near to the peripheral angle) are usually more distinct than in the type lot of *clappi.* A small series of fully adult shells from Station 12 measure:

Alt.	9,	diam.	15.5	mm.
"	8.8,	"	14.5	"
"	8.5,	"	14.4	"
"	8.8,	"	14.8	"
"	9,	"	14.3	"
"	9.2,	"	15.3	"
"	8.7,	"	14.3	"

3. Onion Creek Form.—This form resembles the second form from Cave Creek and *O. c. emigrans* in shape. Compared with *O. clappi* the whorls are flatter, less convex, sutures not so deep. The last whorl invariably falls to the aperture further below the angle of the preceding whorl, and the peripheral angle continues strong as far as the lip-edge.

Cuticle thin, persistent, not ragged or broken, light greenish olive, *lustreless*, with occasional dark oblique lines, which, near the aperture, become crowded. It is seldom banded spirally and then the bands are indistinct, obscure brown and transparent. The growth-striæ are sharper, more distinct than in Cave Creek *clappi*. It is very densely and distinctly striated, spirally. Oblique waved riblets and traces of spiral wreaths on the base, as in *O. c. emigrans*, are shown in young shells, and sometimes upon the penultimate whorl of the mature shell within the aperture, but seldom persistent upon the exterior. There are nearly 5 whorls. The aperture is pear-shaped, its upper margin nearly straight (consequent upon the flatness of the whorls); not arched, as in typical *O. clappi*. The smaller shells measure about 8.8 × 15 mm.; the largest in about one hundred specimens measure:

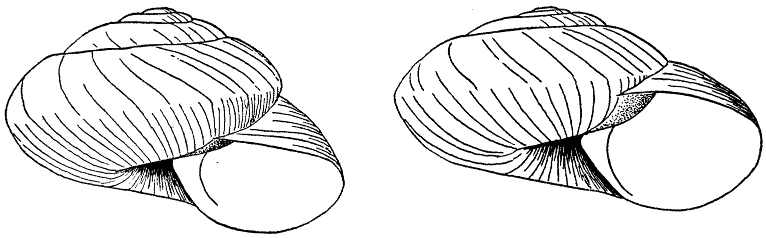


Fig. 8.—*Oreohelix clappi*, lower Cave Creek, Station 12.

Alt. 10½, diam. 17½ mm.
" 10½, " 17 "
" 10½, " 17 "
" 10, " 17 "
" 10½, " 16 "

Found at the head of the main fork of Onion Creek, a branch of Turkey Creek, on the north side of the range. It was found in a shattered column of quartzite in company with *Ashmunella, Sonorella, Succinea avara* and two rattle-snakes, *Crotalus pricei* and *C. lepidus. Oreohelix chiricahuana* dwelt in the limestone over the ridge, less than a half mile distant. The station is about 4 miles from the locality of *O. clappi* and 16 from that of *O. c. emigrans*, and upon a direct line between the two. This is the greenest in color of the group, the texture of the cuticle is the most harsh and it is the largest in diameter.

4. FORM FROM RUCKER CANYON.—The sculpture in this form is weak, the oblique wrinkles smooth, in part effaced, and lower on the base; spiral striation weak or subobsolete, hardly noticeable above. *Cuticle glossy,* persistent, varying from rather bright green or greenish-yellow to brownish-olive, the two brown bands distinct. There are sometimes two fainter bands, one above, the other on the base. The last whorl is only very obtusely angular, the angle, well rounded, usually falls less in front than in the Onion Creek lot. The aperture is conspicuously longer than in typical *O. clappi;* upper margin decidedly arched. In old shells the lip-ends approach closely, but are not connected as in the typical *O. clappi,* the callus between them remaining thin and transparent.

Up to 3½ whorls the young carry five strong cuticular fringes below, one at the periphery and one above. The cuticle in larger shells is smooth.

The largest in 45 measured:

Alt. 10, diam. 16½ mm.
" 10, " 16½ "
" 10, " 16½ "
" 9½, " 15½ "
" 9, " 15½ "

This is the handsomest of the group in color and, with the exception of *O. c. cataracta,* the smoothest, the base being polished with somewhat of a varnish-like gloss. The last whorl is even more rounded peripherally than in typical *O. clappi.* In 1908 it was found in a deep gulch, the "box" of Rucker Canyon, at about 8,000 feet elevation, on both sides of the stream in sliding rock, where the atmosphere was as moist as the stations on Cave Creek, about 12 miles distant. It is a near neighbor with *O. barbata,* a small form of the latter being plentiful at the twin caverns in the box, while *O. clappi* was found half a mile farther down the stream.

5. SHAKE GULCH FORM.—The shell is sharply angular peripherally, the angle becoming obtuse near the lip; whorls flattened above; cuticle dull, lusterless, persistent, obscure olive at the base, the upper surface with a russet suffusion, peristome black-bordered. There are one or two faint bands. The surface is obliquely, rather obtusely, wrinkled, the base distinctly striate spirally, growth-lines low, not waved. The sculpture of the embryonic shell is very weak, and

seems closer than usual. Unfortunately, no young examples were taken.

This form is usually more depressed than that from Onion Creek, with less sharp oblique sculpture. It resembles the remote Onion Creek colony in the lusterless cuticle. Fourteen of about 20 shells taken measure:

Alt. 9, diam. 15.5 mm. (4 specimens)
" 9, " 15.7 "
" 9, " 14.7 "
" 10, " 14.5 " (senile form).
" 9.5, " 16.7 "
" 9, " 14.5 "
" 10, " 17 "
" 9.5, " 17 "
" 9.5, " 16.5 "
" 9.75, " 16 "
" 9.5, " 16 "

Shake Gulch, where these shells were found, is on the southwest side of the range at about 5,500 feet elevation about 12 miles from the Rucker "box."[19] They live in a rock slide near the stream.

6. Horse-shoe Canyon Form.—Similar to the preceding except that the peripheral angle is less acute; between the Shake Gulch and Rucker lots in form. Fragments of a *long cuticular fringe remain in places in the suture* from the third whorl to near the aperture, but there are no spiral series of granules or cuticular prominences on the base, thereby differing from *O. c. emigrans*, and like the forms geographically nearest. Only two collected, both adult, measuring alt. 9, diam. 16 mm.

Found in Horse-shoe Canyon about ten miles from the mouth, in slide rock, on the opposite side of the main fork from the Red Box, at about 7,000 feet elevation. Both shells taken were freshly dead.

Oreohelix clappi cataracta n. subsp.

The shell is *depressed,* nearly lens-shaped; periphery strongly angular, bright olive green, thin, *polished,* translucent, occasionally marked with two transparent bands; 4½ whorls, the last wider than in *clappi,* with the periphery near the flattened top, base strongly convex. Aperture nearly all below the periphery. Parietal callus short, merely a thin film on the penultimate whorl. Cuticle smooth and without "fringes" in young or old, very delicately striated spirally; sculpture of the embryonic whorl delicate, usually worn off.

---

[19] Shake Gulch is so named from the circumstance that "shakes" (split shingles) are there made from the cypress.

Probably only the first of those measured is mature:

Alt. 6.1, diam. 13.8 mm.
“ 6½, “ 12 “
“ 6, “ 12 “
“ 6½, “ 11 “
“ 5, “ 11 “

Found at the Cave Creek Falls in broken rock sprayed by the falls, and near the water's edge, in company with a very small form of *Ashmunella chiricahuana*. It was also found occasionally among the rocks higher up the slide with *O. barbata* and *Ashmunella angulata*. About 25 were found in two visits to the stations. None were alive, but some perfectly fresh. It is probably a deep burrower. This is the only station where *O. barbata* and *O. clappi* were found together.

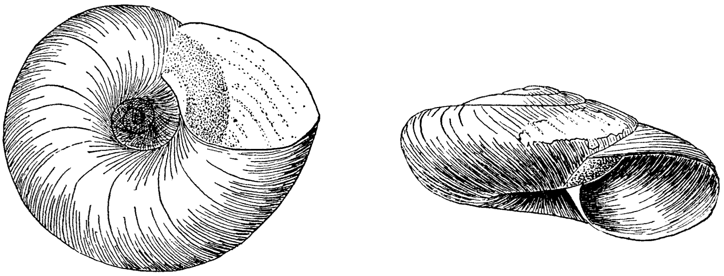


Fig. 9.—*Oreohelix clappi cataracta* P. and F.

O. c. cataracta is quite a distinct race. The green, polished base reminds one of *Omphalina*. It is the smoothest and most depressed form of *O. clappi*.

Oreohelix chiricahuana Pilsbry. Fig. 10.

Proc. A. N. S. Phila., 1905, p. 283, pl. XI, figs. 1–3 (shell), pl. XIX, fig. 4 (genitalia), pl. XXIII, fig. 24 (jaw).

The range or this species extends from Emigrant Canyon to Limestone Mountain, a distance of about 50 miles. Its range is markedly discontinuous towards the north and south ends, but from White Tail to Cave Creek Canyons the colonies are not widely separated. It is always found on limestone, never where the country rock is metamorphic or igneous.

The several races differ as follows:

a.—Sculpture of sharp fine striæ along the lines of growth, conspicuous on the base, where there are also spiral striæ and some widely spaced larger spirals.
  b.—Shell smaller, diameter about 11 mm., whorls 4½ to 5; peripheral keel well expressed.. *O. chiricahuana.*
  b^1.—Shell larger, diameter about 14 mm., whorls 5¼; peripheral keel strongly projecting, the whorl hollowed above and below it.. *O. c. percarinata*
a^1.—Sculpture obsolete, the oblique striæ course and blunt, the base especially much smoother; spiral sculpture weak or wanting; diameter usually 12 to 15 mm., whorls 5⅓ to 5½........ *O. c. obsoleta.*

The type locality is on the slope with southern exposure below the cave in Cave Creek Canyon, Station 8 on map, p. 107. The dry ravine has steep sides of steeply dipping, more or less calcareous shale and earth formed by its decomposition. The dead shells are profusely scattered; living ones are under dead mescal (*Agave*), sotol (*Dasylirion*) and bear-grass, with *Thysanophora horni*, *Succinea avara*, *Vitrea indentata* and *Holospira*. The colony here is about 250 yards long and perhaps 100 wide in the widest place. The shells are very uniform in size:

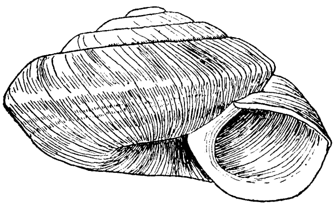


Fig. 10.—*O. chiricahuana*, Cave Creek, Station 8.

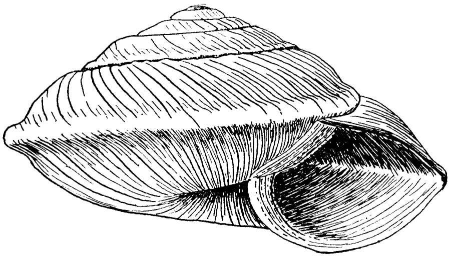


Fig. 11—*O. c. percarinata* P. and F., Cross J Mountain

Alt................................	6	6.8	6.5	6.5	6.8	6.8 mm.
Diam.............................	11.1	11	11	11	10.5	11.5 mm.

The shells are white, with the earlier whorls flesh-tinted, a faint fleshy-corneous band at the outer third of the top of the last whorl, which has two grayish or fleshy corneous bands on the outer half of the base or a general fleshy corneous suffusion there. A scalariform mutation rarely occurs.

From the cave we found large colonies at intervals westward nearly to the western rim of the valley, at Stations 5, 6 and 7 on map, p. 107. At Station 5, on a steep north slope along the creek, under rocks, about 3 miles west of the cave, the shells are similar but larger, 12 to 13 mm. in diameter.

At Station 6, about half way up the north side of the limestone ridge, the shells were like those from the cave in size, but somewhat whiter, more calcareous. Near and at the top of the ridge, along the southern side, east and west of station 7, *O. chiricahuana* is widely distributed. The shells here are like those from Station 6, but smaller, the largest 10 mm. in diameter. This colony is probably 1,500 feet higher than the cave. The smaller size of the shells from Station 7 may probably be correlated with a dryer and hotter habitat. How far down the south slope it extends we did not learn. We found *O. chiricahuana* nowhere else in Cave Creek Canyon, nor has the typical form been encountered elsewhere.

Oreohelix chiricahuana percarinata n. subsp. Fig. 11.

The shell is larger than typical *O. chiricahuana*, whitish, clouded and suffused with flesh color, depressed, with *a compressed, projecting peripheral keel*, the last whorl excavated, concave above and below the keel, elsewhere strongly convex. Striation oblique, rather coarse and quite irregular above, sharper and strongly arcuate below.. Spiral threads few and fine or wanting on the upper surface; on the base there are two to four major spirals at wide intervals, with fine spiral threads over the whole base. The last whorl rarely falls far below the carina at the aperture. Alt. 8, diam. 14 mm.; whorls 5¼.

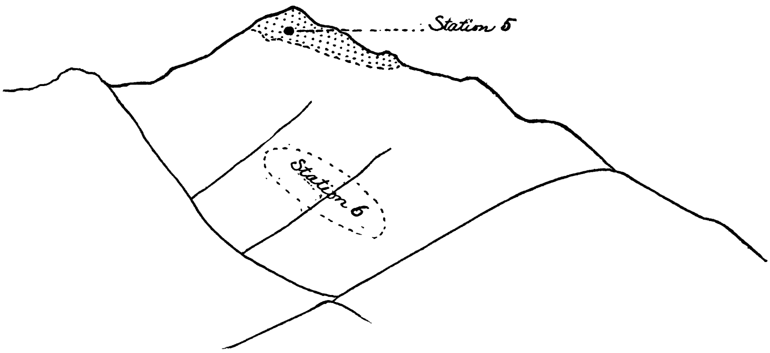


Fig. 12.—Summit Cross of J Mountain, seen from the mouth of Big Emigrant Canyon, at X on map, p. 121. Entire range of *O. c. percarinata* shaded. At Station 5 and over much of the slope around Station 6, *Sonorella optata* was found. High granitic spur on left.

Summit of Cross J Mountain near the mouth of Big Emigrant Canyon, Station 5 on map, p. 121. November 12, 1906. This locality is farther north than any other known colony of *Oreohelix* in the Chiricahua range. The Oreohelices were found around the summit, which is probably about 7,500 feet elevation, and along the ridge northward, down about 500 feet, but not in the valley (Station 6), where *Sonorella* lives. This slope of the mountain is limestone, becoming cherty above, but the summit is angular, friable quartzite (?), among the fragments of which the Oreohelices live. None were found on the ridge running toward the mouth of the canyon, which is composed of a disintegrating, coarse-grained granitic rock. There is little vegetation of any kind on the upper part of Cross J Mountain. The station is rocky, barren and exposed. The snails are moderately abundant, though living ones are hard to get.

Paradise Canyon. On the south side, about two miles below the town of Paradise, *Oreohelix* was found in some abundance, but owing to the snow which covered the ground at the time we camped there (November 20) but few living examples were taken. The form is almost identical with that of Cross J Mountain, the adult differing only in having the radial striation on the base a little more regular, and the major spirals, of which there are three or four, often somewhat stronger, though in some shells they are hardly noticeable. In young and half-grown shells a thin cuticular thread runs along the summit of each of the striæ, and at the intersections of the major spirals these threads rise in short triangular processes. This feature was not observed in the shells from Cross J Mountain.

Another similar lot was taken on the northern slope of the canyon. These places are probably not far from the 6,000 feet contour, being thus much lower than Cross J Mountain.

The separation of these colonies from the Cross J Mountain colony of *O. c. percarinata* probably indicates independent evolution of the same characteristics, since an area occupied by *O. chiricahuana obsoleta* lies between Big Emigrant and Paradise Canyons.

Oreohelix chiricahuana obsoleta n. subsp. Fig. 13.

In White Tail Canyon, this form of *O. chiricahuana* was taken at Stations 1, 2, 3, 6, 7, 8, 12, 14—all on the southern side except 3, which is just over the crest of the ridge on the Pinery side. The sculpture is rather rude and blunt, the striation less sharp than in the Cave Creek form, being effaced or subobsolete especially on the base where spiral lines are wanting or rarely weakly indicated, while Cave Creek *chiricahuana* has sharp, subregular striation and distinct spirals. Two or three inner whorls are brown, the rest being white with some faint gray streaks and scattered dots. Whorls 5⅓ to 5½ (4½ in typical *chiricahuana*), the last carinated as in *chiricahuana*. The shape varies from typical to decidedly more elevated, and the size everywhere exceeds that of Cave Creek shells. A series from the typical Station 14, where it is abundant, measures:

Alt.	9.7	9	9.5	9	9.5 mm.
Diam.	15	15	14	14.2	14.2 mm.
Whorls	5⅓	5⅓	5⅓	....	....
Alt.	10	9.2	9.8	9	8.7 mm.
Diam.	14.2	14	13.5	13	12 mm.
Whorls	....	....	5½	5½	5⅓

In these shells the peripheral angle is about as in Cave Creek types, but the base is smoother, the striation nearly effaced, and spiral striæ are wanting or very rarely a few may be faintly seen under the keel. Shells from Stations 1, 2, 6, 7, 8, 12 agree with those from 14. These stations are on rather steep slopes with generally northern exposure, and from somewhat over 6,000 to about 7,000 feet elevation. The distribution over this area is nearly or quite continuous.

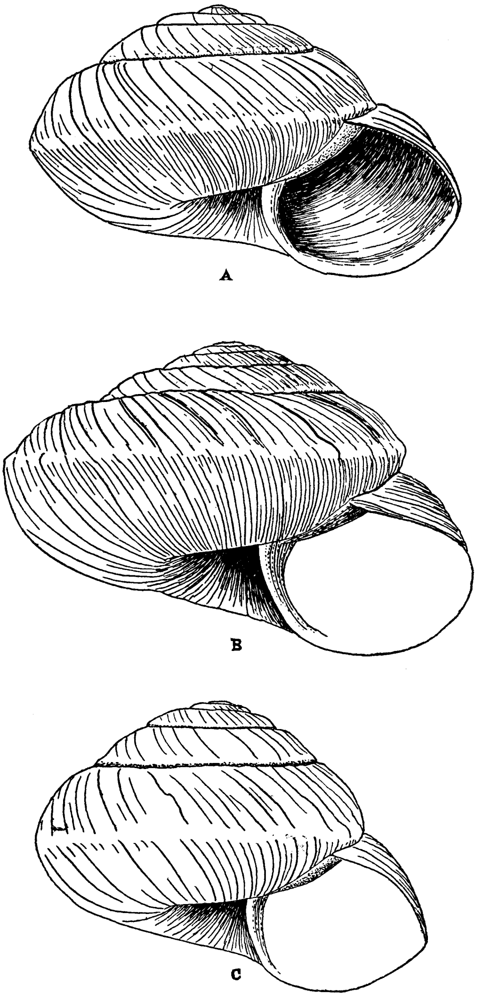


Fig. 13.—*O. c. obsoleta* P. and F. A, White Tail, Station 14; B, C, Limestone Mountain. Drawn to same scale as figs. 10 and 11.

At Station 3, just over the crest of the ridge, on the Pinery Canyon side, probably a little over 7,000 feet elevation, the shells are smaller, 11.8 to 13 mm. diameter; otherwise similar. This station is very high and exposed, on a sunny slope, hence extremely dry and arid; but the following record shows that mere elevation is not a factor of importance. On the south side of White Tail Creek, only a few feet above the bed of the canyon, at and below the mouth of Indian Creek, the shells are equally small, 12 to 13 mm. in diameter. The station is deficient in herbage, more barren than higher up the slopes.

In the Box Canyon of White Tail we found a colony which differed from all other lots of the White Tail region in sculpture, the striation being distinct and rather sharp on the base, as in typical *chiricahuana*, and with very weak traces of fine spiral lines. The peripheral keel projects more, approaching the shape of the race from Big Emigrant Canyon; otherwise the shape, size and number of whorls is as in *O. c. obsoleta*. The conditions at this station were unfortunately not noted particularly.

No specimens of this shell were taken by Ferriss and Daniels in 1907, as they did not explore the limestone ridges. In 1908 Ferriss and Pomeroy found it again in Hand's Pass, over the range from White Tail, in the head of Pinery Canyon.

The embryonic shell is strongly, regularly ribbed. The shell has 5¼ whorls, rounded, arcuate, keel nearly obsolete near the aperture in mature shells; aperture nearly round, the angle formed by the peripheral keel hardly perceptible.

Alt.	10½	10¼	10¼	10	8¾
Diam.	16	14½	14½	15½	14

They were found for several miles upon both sides of the trail in the scattered stone upon the hillsides and around the cliffs.

In the head of Mackey's Wash, sloping to the north, a few were found, but no aged shells. The major spirals upon the under surface are represented by very low, obtuse ridges. The keel becomes very obtuse on the last whorl near the aperture. *O. c. obsoleta* was also found in the head of Onion Creek (between Paradise and Jhu Canyons).

In 1907 Mr. Ferriss passed over the wide part of the range from Paradise to the mouth of Rucker Canyon and Shake Gulch, some 25 miles from the Cave Creek Station, and here again *O. c. obsoleta* (fig. 13 *b*, *c*) was found in a foothill known as Limestone Mountain, about ten miles in length and some 7,000 or 7,500 feet above the sea. These are the largest specimens so far found, thick and rounded, opaque white or pink-white and very little clouded. The wrinkles were coarse but obtuse upon the upper surface, the base smooth, without a trace of spiral lines.

Alt.	11	10¼	11	12	9
Diam.	16¼	16	15½	15½	15
Whorls	5½				

In "Canyon No. 3" (not knowing a better name) the shells were sometimes specked with transparent dots.

Alt	11¼	11¾	11¼	10¼	10
Diam	16½	16¼	16	16	15½

Limestone Mountain is thickly covered with juniper, mountain mahogany and other trees and shrubbery, for it is in a U. S. Forestry Preserve. The shells were found in the upper part of the mesa before the rough ground was reached, in company with *Holospira,* but small in size. As the hill became higher the shells were larger and more numerous. Here also was found a toothed form of *Ashmunella* and also Pupæ and other of the smaller species. The mountain is composed entirely of limestone, upon the northern slope at least. Rocky cliffs and talus gave the snails ample shelter. Between this station and the Cave Creek Station, about 25 miles distant, there are no limestone exposures and no *Oreohelix chiricahuana.*

Oreohelix barbata Pils. Pl. VI, Figs. 1–3.

Oreohelix barbata Pils., Proc. A. N. S. Phila., 1905, p. 280, pl. 25, figs. 57, 58 (shells); pl. 19, figs. 5 (genitalia); pl. 22, fig. 6 (teeth).

Twenty colonies of this species have been found, all between the head of the southeast fork of Pinery Canyon and the Rucker "box," at elevations of not less than 7,000 feet, and within a distance of twelve miles in length and two to three miles in width. They dwell upon all sides of these high peaks in the rock slides or talus, and among the rocks upon the slopes of the gulches and ravines. Ferriss and Daniels found the most robust specimens living under from two to three feet of rock well covered over with sod, with the most perfect specimens of *Ashmunella chiricahuana*, a toothed *Ashmunella*, *Sonorella virilis* and the little mountain rattle-snake, *Crotalus pricei.* In Cave Creek Canyon they often occur under one or two feet of rock.

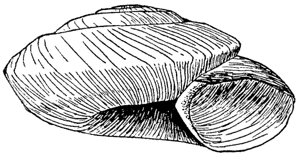


Fig. 14.—*O. barbata,* denuded shell from Cave Creek, Station 4.

In their own territory *Ashmunella, Sonorella* and the other forms of *Oreohelix* are usually to be found wherever the conditions are favorable; but it is not so with *O. clappi* and *O. barbata.* These snails are found only by chance, in isolated colonies, and these colonies are usually divided into families, the old pair and their spring crop of all sizes when not fully matured live together.

Every colony as a rule has some peculiarity. *O. barbata* ranges in color from pale greenish to dark reddish brown, some with wide indistinct red bands. Many lose their fringes and part of the cuticle before maturity. In one colony the shells were entirely naked. The rows of cuticular fringes vary in number from five to ten. In size, the shells are from 14½ mm. diameter down to 10 mm. in the race *minima*. Elevation above the sea apparently does not control size. The smaller forms usually dwell at 10,000 feet, and the largest at 7,000, but a pigmy form was found at the lowest altitude, and the most robust at about 8,500 feet.

The deflection or dropping of the last whorl at the aperture is not uniform or consistent in any colony, but it has significance in connection with the proportion of individuals so modified. In some colonies, as that in Cave Creek, the last whorl as a general rule drops very little, while in Barfoot Park it usually descends deeply.

In Cave Creek Canyon this species is confined to the border and slope of the western escarpment. Ferriss (1904) took the types in the talus half a mile below the falls of Cave Creek. These have 4⅓ whorls, and are pale greenish; the cuticular laminæ light russet. There are four to six, usually five, circular wreaths of triangular cuticular scales, one small one being midway between periphery and suture, but often wanting, one at periphery, and three or four on the base.

The last whorl is strongly angular throughout, and usually does not descend very deeply in front. Parietal callus thin and moderately long.

Alt. 7, diam. 13.5 mm., not including cuticular processes.
" 5, " 12 mm.

In 1906 we found almost similar specimens at Station 4 (marked by two dots on the map, p. 107), darker in color, with sometimes as many as eight cuticular wreaths, sharply carinated or angular at the periphery. These were on a well-shaded northern slope, under rocks in a coarse talus. This place is two or three hundred feet above the bed of the "wash" and about one hundred below the cliffs, just opposite a little grove of aspens among the oak scrub, which form a conspicuous landmark near the head of the "wash," from their rarity in this canyon. The snails here had been preyed upon by the mice.

In Turkey Creek near the head of one of the eastern branches at an elevation of about 8,500 feet, Ferriss and Daniels took fully developed examples in 1907 (pl. VI, figs. 1, 2, 3). The shells are strongly angular to the aperture, and measure 13 to 14½ mm. diameter, with 4½ to 4¾ whorls. They have 7 beautifully developed wreaths in the best preserved individuals. The last whorl drops fully 2 mm. at the aperture. They were found in a talus upon an eastern slope of a steep mountain side, and possessed the best developed, longest and most persistent cuticular wreaths.

A second colony in the head of one of the eastern forks of Turkey Creek, found in 1908, approaches more closely the Barfoot Park series. The shell is greenish under a pale brownish cuticle with a red band; five short cuticular wreaths; last whorl drops 1 mm.; margins of aperture connected by thick callus. Diam. 12, alt. 7 mm.

These snails live in numerous colonies around the region of the Falls of Cave Creek and the heads of the branches northward as far as Turkey Creek. As the original photographic figures do not show the shape clearly, a new figure has been drawn (fig. 14) of a shell denuded of cuticular fringes, from Cave Creek, Station 4.

Blunt-edged Variety.—In Barfoot Park, Rustler's Park, at about 9,000 feet, a slide at the head of Turkey Creek, Ash fork of Cave Creek, Snow-shed Mountain at the head of Cave Creek, and the head of Rock Creek, a form occurs in which the shell is smaller than typical *O. barbata* and in fully adult shells the last whorl often descends the full width of the former whorl: the periphery also is somewhat less sharply angular, and becomes almost rounded near the aperture.

Alt. 5.5, diam. 11.3 mm., Station, Barfoot Park.
" 6, " 11 " " " "

This is distinctly a decadent form, as denoted by the tendency of adult shells to assume the old-age feature of a very deeply descending last whorl. In Barfoot Park it lives in a deep slide of igneous rock having a southern exposure. In Rustler's Park in a few stones on the hillside.

On the Ash fork of Cave Creek a colony has 4½ whorls, the shell is white under the cuticle, which is dark reddish brown above, lighter brown below; occasionally with five cuticular fringes; last whorl drops 1 mm. Diam. 12, alt. 6½ mm., aperture 4¼ mm.

A colony at the spring branch of Rucker Canyon, north side and near the head, Station 10*a*, resembles the above closely (pl. VI, figs. 4, 5). The umbilicus is a little more open, cuticle dark reddish brown, banded with red above; six cuticular fringes. Diam. 12½, alt. 6 mm. It is strongly angular to the aperture, and the last whorl falls much more in front than is usual in Cave Creek shells.

In a slide of rock on the north side at the head of Raspberry Gulch (a tributary of Rucker Creek, which it enters at the Box Canyon) a colony had only 4 whorls. The umbilicus measured 3½ mm. wide. Cuticle dark reddish brown, with a short fringe on the periphery; last whorl drops 1½ mm. Diam. 12, alt. 6½.

On the west slope of Snow-shed Mountain, at the head of Cave Creek, almost one continuous talus, was a colony similar to the preceding. Shell transparent when young, occasionally with 5 short fringes. Diam. only 10½, alt. 5¾ mm.

In a dry talus fully exposed to the sun and sloping to the south on the head of Rock Creek was a colony heavily covered at maturity with 9 or 10 black fringes, periphery rounded as in the Rustler Park and Barfoot Park specimens; aperture 4½ mm. Margins connected by a thick callus; umbilicus varies from 3 to 3½. Diam. 11, alt. 6¼.

The five colonies above were found by Ferriss in 1908.

In 1907 Ferriss and Daniels found a small heavily fringed form in the talus of a gulch in the head of the southeast fork of Pinery Canyon, that in fringes resembles the type of *barbata*.

Like the above it had from 9 to 10 long fringes. The last whorl dropped but one mm. Diam. 11, alt. 6, aperture 4 mm.

Oreohelix barbata minima n. subsp. Pl. VI, figs. 6, 7.

At the head of Rucker Canyon (Station 11½A) and in the Rucker Box, Ferriss and Daniels found colonies in 1907 that were still further depauperate than the above. Ferriss relocated the latter colony in 1908. These shells possess 4¼ to 4½ whorls, the last whorl regularly angular, the angle weakening near the aperture in old shells. Toward the end the whorl falls deeply at maturity. There are from 6 to 7 spiral fringes in the best preserved examples, but adults generally are denuded or show only traces of the spiral wreaths. The margins of the lip converge and form a perfect union in maturity, being joined by a very short parietal callus, and the aperture is sometimes raised above and free from the penultimate whorl.

The shells from the head of Rucker are uniform brown in color and measure:

Alt. 5, diam. 10.3, umbilicus 3, diam. aperture 3.5 mm.; whorls 4½
" 5, " 10, " 3.1 " " 3.25 " " 4⅓

Those from Rucker Box are light brown, sometimes albinistic, light green.

Six specimens from the Box of Rucker Canyon, type locality, measure:

Alt.	5.8	5.25	6	5.25	5.25	5
Diam.	10	10.5	10	10	10	10

This is the most decadent race, being reduced in size in addition to the deeply descending last whorl and in old shells the nearly or quite free peristome. Colonies of larger forms of *O. barbata* occur at greater elevations than the Rucker Box (about 7,000 feet), so that the degeneration is probably due to other local causes.

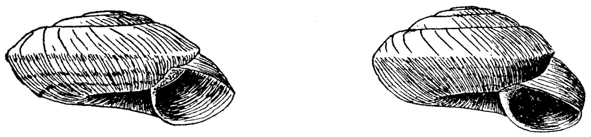


Fig. 15.—*O. b. minima* P. and F., Rucker Canyon, Station 11½*a*.

Genus **ASHMUNELLA** Pils. and Ckll.

A study of the genitalia of Chiricahuan Ashmunellas leads to the conclusion that all the species of that range are of common ancestry, and more closely related *inter se* than any are to New Mexican or Huachucan species. In other words, the specific differentiation has been mainly subsequent to the isolation of this fauna.

In both Chiricahuan and Huachucan species the penis is bipartite, consisting of an upper and a lower portion separated by a submedian constriction. In the Huachucan series the *upper segment is enlarged* like the lower (see plate XX, Proc. A. N. S. Phila., 1909). In Chiricahuan forms the upper segment of the penis is *very narrow*, hardly larger than the epiphallus, but its distal end is invariably a little swollen, and contracts abruptly where it passes into the epiphallus[20]. The penis retractor is extremely short in Chiricahuan species, longer in Huachucan. The spermatheca is more or less varicose in Huachucan species, but this is hardly apparent in Chiricahuan forms. The vagina in the Chiricahuan series is swollen and muscular in its upper part, smaller with thinner walls below. In other respects the organs are alike in the two series. These considerations lead to the conclusion that the whole Chiricahuan series of *Ashmunella* constitutes one phylum, the Huachucan series another. Doubtless the two phyla were of common ancestry; but their evolution on the two parallel mountain ranges has been independent. The extraordinary resemblances between some Chiricahuan and Huachucan species, which led us in 1905 to

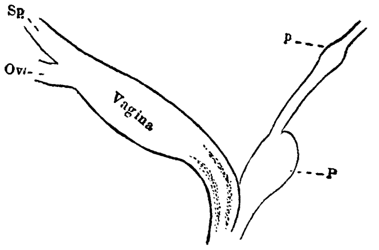


Fig. 16.—Terminal ducts of genitalia of *Ashmunella p. albicauda*, Station 4, White Tail Canyon. *Sp*, base of spermathecal duct; *Ovi*, base of oviduct; *P*, lower, swollen portion of penis; *p*, upper end of penis.

---

[20] The slender upper continuation of the penis was not always recognized in our former (1905) work on Chiricahuan snails, although once understood it is clear enough.

unite some of them specifically,[21] are wholly due to evolution along parallel lines in the two stocks. This orthogenetic evolution has resulted in the most extraordinary parallelism. By degeneration of the teeth of the aperture, wholly toothless forms have arisen as terminal evolution products in both phyla; and these are so similar in shell-characters that they are indistinguishable. Other forms in both phyla have evolved a V-shaped parietal tooth, like that of *Polygyra.*

While the shell is extremely conservative in *Sonorella,* in the related genus *Ashmunella* it appears to be the most plastic part of the organism. As in *Polygyra* and many other molluscan groups in which complex hard parts have been evolved, many races and species are characterized by varying degrees of degeneration of the teeth of the aperture. In the current phraseology, this may be due to the action of an inhibiting factor, earlier or later checking the development of teeth. This seems to have taken place independently in most of the centres of *Ashmunella* evolution. Toothless apertures are no doubt primitive in the Belogenous Helices, so that secondarily simplified forms, such as *A. varicifera* and *A. chiricahuana,* have completed an evolution cycle, returning to the primitive simplicity of aperture. Whether such forms can give rise to new series having dentate apertures remains uncertain.

Key to Chiricahuan Ashmunellas.

I.—Aperture toothless or with very small vestiges of teeth only.
  a.—Shell chestnut brown, glossy, the lip narrow, without traces of teeth..*A. chiricahuana.*
  *a*¹.—Shell light brown without much luster; usually with a callous ledge within the outer lip, or other weak vestiges of teeth. *A. esuritor.*
    b.—Penis normal.
    *b*¹.—No penis; vagina long, much swollen above..*A. metamorphosa.*
II.—Aperture obstructed by three or four large teeth.
  a.—Very acutely carinate, the carina projecting above the suture; whorls of the spire flat..*A. ferrissi.*
  *a*¹.—Carina not projecting at sutures or wanting.
    b.—Surface papillose or scaly; shell thin, strongly carinate. *A. lepiderma.*
    *b*¹.—Surface not scaly or conspicuously papillose.
      c.—Basal tooth single, bifid, or with two basal teeth nearer together than the outer one is to the outer lip tooth.
        d.—Periphery obtusely angular in front, becoming rounded; young with a slight lip-rib only..............*A. duplicidens.*
        *d*¹.—Periphery strongly angular or carinate.

---

[21] In 1905 we considered the Chiricahuan *Ashmunella proxima* to be a subspecies of the Huachucan *A. levettei.* The Huachucan *A. varicifera* we thought identical with the Chiricahuan *A. chiricahuana.*

e.—Whorls fully 6; lip narrow, convex, not forming a projecting angle above........................*A. p. fissidens.*

e^1.—Whorls 5½; lip wide, angulated above; young forming a very heavy lip-rib............................*A. p. albicauda.*

c^1.—Three lip teeth separated by nearly equal spaces.

d.—Corneous or light brown; whorls of the spire convex; outer basal tooth not greatly compressed.

e.—Corneous; basal teeth subequal and well separated. *A. proxima.*

e^1.—Basal teeth somewhat united, the inner often reduced. young shells having a very heavy lip-rib. *A. p. emigrans.*

d^1.—Shell dark brown; whorls of the spire flattened; outer basal tooth strongly compressed, entering.*A. angulata.*

The genitalia are very similar in all Chiricahuan species examined—so similar that we omit detailed descriptions and merely add here a table of measurements in mm. of the organs in examples of the several species.

Species and locality.	Penis.	Epiphallus.	Vagina.	Sperma-theca.	Diameter of shell.	Figure of genitalia.
A. ferrissi:						
Cave Creek, 94,515................	4.5	25	4	19.5	12	pl. X, f. 7
A. angulata:						
Cave Creek, 87,020................	4	31	4	27	11	pl. X, f. 6
A. lepiderma:						
White Tail Canyon................	5	25	4	17	12	
" " "	5	27	4	21	11.5	
" " "	4.5	23.5	6	23.5	11	
A. duplicidens:						
Morse Canyon..........................	6	39	4	18	13.2	pl. X, f. 8
A. fissidens emigrans:						
99,604......................................	6	32	3.5	24	13	pl. X, f. 9
A. fissidens albicauda:						
White Tail..................................	5	29	4.5	24	12	
A. chiricahuana						
Head of Cave..........................	9	70	6.5	58	19.5	pl. X, f. 4
Cave Creek Falls....................	5.5	33	8	33	15	pl. X, f. 1
A. esuritor:						
Barfoot Park, 94,432............	7	51	6	35	15–16.5	pl. X, f. 2
" " "	8	40	7	42	"	
" " "	8	42	6.5	42	"	pl. X, f. 5
Topotype, 92,205..................	5	34	4	....	15	pl. X, f. 3

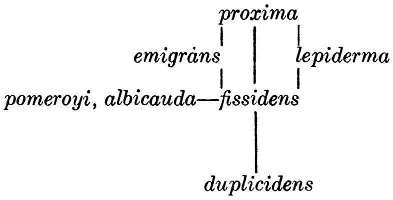
Group of Ashmunella proxima.

From Old Fort Bowie these forms extend southeastward to the end of the Chiricahua range. Northward beyond the depression at the Fort, in the Dos Cabezas end of the range, no *Ashmunella* has been found. The mountains here are apparently too barren and dry for *Ashmunella,* though they support the more hardy Sonorellas.

The colonies seem to be small and widely separated in the area northwestward of White Tail Canyon, but much of that country remains to be explored, especially between Big Emigrant and White Tail Canyons, as well as the entire region of the southwestern watershed.

A. ferrissi and *A. angulata* are distinct from the others by their flattened whorls and conspicuously compressed outer basal tooth. The other species are intimately related, and their variations make a complexly branching form-chain. An adequate study of the material in hand, some thousands of shells, would require more ample time than we can give. Since not half of the territory is adequately covered by our series, we must leave full consideration of the subject for another occasion.

Our knowledge of the forms from Rucker and Horseshoe Canyons and the region around them is still very defective. The forms seem to be related somewhat, as shown in the following diagram:



If a single basal tooth is primitive, then *A. duplicidens* is the least evolved member of the series and of the whole Chiricahuan group of Ashmunellas. Then *A. proxima* and *lepiderma* would be the most evolved. All of the forms with more or less concrescent basal teeth are extremely variable in the degree of union of these teeth. Every colony of *fissidens, emigrans, albicauda, pomeroyi* and *duplicidens* shows great individual variation in this respect. There seems to be complete intergradation between the separated basal teeth of *proxima* and the united teeth or single tooth of *fissidens* and *duplicidens.*

Ashmunella lepiderma n. sp. Pl. VII, figs. 1–7.

Shell umbilicate, the umbilicus about one-fifth the total diameter of the shell, much depressed, biconvex, acutely carinated peripherally, thin, corneous-brown. The surface is lusterless, sculptured with fine, unequal wrinkle-striæ, and covered with a network of cuticular scales or processes (readily removed by cleaning). There are 5½ whorls, the first one corneous and glossy, the first three convex; subsequent whorls convex above, impressed above the lower suture; last whorl is distinctly impressed above the projecting peripheral keel, the base convex; in front it descends slightly or not at all to the aperture, and is narrowly, rather deeply, guttered close behind the lip on the base. The aperture is lunate, contracted by four teeth: a wide one within the outer lip, two contiguous tubercles in the basal lip, and an oblique straight parietal tooth. Parietal callus thin and transparent.

Alt. 4.8, diam. 11.7 mm.
" 4.2, " 11.2 "
" 5, " 11 "
" 5.5, " 12.2 "

White Tail Canyon, *on the northern side only*, at Stations 10, 11, 16, 17, etc., in "slides" of igenous rock (rhyolite); type locality, Station 11, in a slide of angular rhyolite, coming down to the trail in the bed of the canyon, with *Sonorella micra*. See map on p. 75.

Genitalia are of the type usual in the *fissidens* group. The epiphallus and spermatheca are a little shorter, proportionately, than in *A. p. albicauda* or *emigrans*. Measurements of the organs of three individuals may be found in the table on p. 97. The mantle within the last whorl is cream-white with a few inconspicuous gray dots; collar pale slate-tinted.

This species, of which several hundred specimens were taken, inhabits suitable rock-slides over the whole northern side of White Tail Canyon. At Station 11 it occurs close to the bottom of the canyon, and only a short distance from where *A. fissidens* is found on the opposite side. The slopes of this side of the canyon are steep, interrupted by cliffs, and the heights are difficult of access. At Station 16 there are extensive rock slides sloping northward towards the mesa, and perhaps 1,500 feet higher than Station 11. Here it passes over the ridge and inhabits the opposite slope. While belonging to the *fissidens* group, this species is very distinct by its sculpture of cuticular scales, the strong carination, thin texture, etc. The young shells form only a weak callous rib within the lip at resting periods.

At all the stations there is considerable variation in size and, as in all Chiricahua Ashmunellas, the height of the spire varies a good deal among individuals of any colony. At Station 17 the shells average smaller than in other places, about 4 x 10.3 mm.; but a few are as large as 11.5 mm. diameter and many as small as 9.5 mm. The scale-like sculpture is especially well developed in shells from this station. In some colonies the cuticular scales are minute, sparse or even wanting in adult shells.

At Hand's Pass, at the head of Jhu Canyon, this species reappears. The surface is regularly very minutely pustulate, some perfectly fresh shells having minute cuticular appendages on the pustules in places. There are also some cuticular spiral hair-lines on the base. Alt. 5, diam. 12 mm., whorls 6. This colony is separated from the type locality by the whole southern slope of White Tail Canyon, where *lepiderma* certainly does not occur. We have considered the possibility that the Hand's Pass form may be an independent convergent modification of the *proxima* stock; but in the absence of alcoholic material permitting a full comparison this hypothesis must remain in abeyance.

Ashmunella proxima Pils. Fig. 17.

Ashmunella levettei proxima Pils., Proc. A. N. S. Phila., 1905, p. 242.

This species was described from "Sawmill Canyon," otherwise known as Rigg's or Pine Canyon, where the senior author collected it in 1904. We did not find it there in 1906, but our search was impeded by snow. We found it near Fort Bowie in company with *Sonorella bowiensis*. The exact locality is a little thicket of long-leaved scrub oaks, just below a low rock-wall, somewhat more than half-way up "Quartzite Hill," on the side facing Dixon's house, shown at (1) in the sketch on p. 67. This is about a mile from Old Fort Bowie.

Similar shells were also taken at Crook's Peak (Ferriss and Daniels) in 1907; only two specimens.

In ranking *A. proxima* as a subspecies of *A. levettei*, a wrong estimate was made of its affinities. It is related to *A. fissidens* and *duplicidens*, but differs from both by having two distinctly separated teeth on the basal lip. *A. levettei angigyra* stands very near *proxima* in shell-characters, but the lower end of the tooth within the outer lip *runs inward* in *angigyra*, while in *proxima* the free edge of this tooth runs parallel with the peristome. In *angigyra* the outer-basal and outer lip tooth are usually closer together than are the two basal teeth. This is not the case in *proxima*, in which the three teeth are about equally spaced. In soft anatomy the two are quite distinct. *A. l. angigyra* has a far longer penis of different shape and a shorter epiphallus and vagina than *A. proxima*; moreover, *angigyra* has a radula with more teeth, and there are more ribs on the jaw. The shell is corneous-brown, subacutely angular at the periphery, the angle weakening on the last part of the whorl, behind the lip, where the surface is more strongly striate. Spire convex. There are 6¼ to 6½ very slowly widening, slightly convex whorls, the last descending somewhat in front. The aperture has a rather long, concave-topped tooth within the outer lip, its face concave. The basal lip has two tubercular teeth, a little compressed laterally, the inner one smaller. These teeth divide the lower border of the aperture into three *nearly equal bays.* The parietal tooth is straight or slightly bent inward at the axial end; never V-shaped, as it frequently is in *A. fissidens.* Parietal callus thin. The umbilicus is rather wide, contained 4¾ times in the diameter of the shell. The surface is rather dull, finely striate, the striæ appearing more or less irregular or interrupted under a strong lens. The size varies little from 12 mm. diameter.

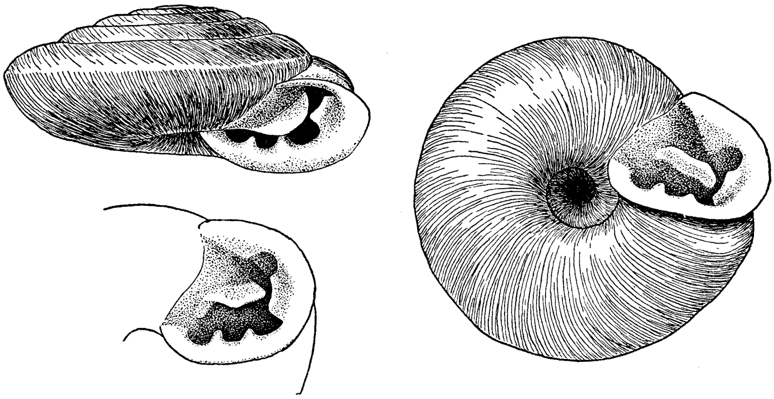


Fig. 17.—*Ashmunella proxima,* Quartzite Peak, Station 1.

In perfectly fresh young shells a delicate pattern of minute low granules on the upper surface may be seen with some difficulty. Some very weak traces of spiral striæ may sometimes be made out on the base. The young shells have a callous rib within the lip, at resting stages, but it is apparently not formed as frequently as in *A. fissidens.*

The genitalia were figured in 1905, pl. 21, fig. 24. Having again examined the individual dissected, we note that the penis was incorrectly drawn. The swollen basal half is everted (as in pl. 21, fig. 23), hence does not show in the figure. The slender upper portion of the penis is shown, its distal end indicated by a slight node, only indistinctly drawn in my figure. With these corrections, it will be seen that the organs are like those of *emigrans, fissidens* and *albicauda.*

The mantle within the last whorl is white, with the anterior vessels of the lung faintly traced in gray and having gray pigment along the periphery.

Southern forms resembling A. proxima.—Raspberry Gulch. A few specimens in poor condition are intermediate between *proxima* and *fissidens* as to the basal teeth, but the umbilicus is much narrower than in either, and the peripheral angulation is less pronounced, thus approaching *A. duplicidens.* There are over 6 whorls. Other southern localities for forms of *A. proxima* are Rucker Canyon and "Turtle Head," a station between Crook's Peak and the mouth of Rucker.

A. fissidens should by rights be subordinated to *proxima* as a subspecies, on account of the various intermediate forms; yet the status of the races can be more clearly expressed by the artificial device of making it a "species."

Ashmunella proxima emigrans n. subsp. Fig. 18.

On Big Emigrant Mountain, Big Emigrant Canyon, a race was found having some characters of *A. fissidens.* The shell is somewhat larger than *proxima,* more robust, with slightly less than 6 whorls. The two basal teeth are less separated, somewhat united by a callus at their bases, and the inner one is generally smaller, frequently very small. There is often the weak trace of an upper branch, making the parietal tooth V-shaped. Fine spirals may be seen on the base of the shell. The young shell forms a very strong callous rib within the lip, as in *A. fissidens.* The umbilicus is narrow, contained five times in the diameter of the shell. Alt. 5.8, diam. 13.2 mm.

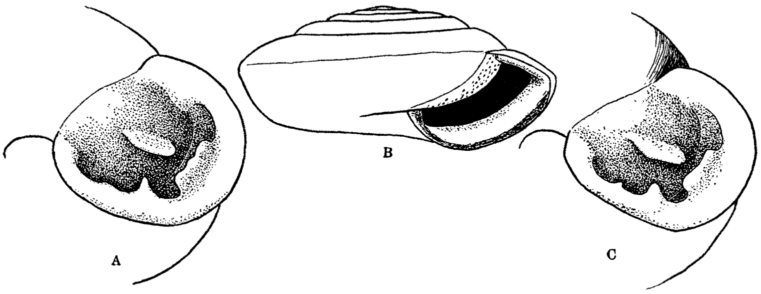


Fig. 18.—*A. p. emigrans.* A, C, apertures of adult shells. B, young shell 11 mm. diam. Big Emigrant Canyon.

This shell is like *A. fissidens* except in the single character of having the basal teeth more widely separated. As in that species, the inner of the two basal teeth is quite variable in size. It is a race intermediate in character between *fissidens* and *proxima.*

Genitalia (pl. X, fig. 9) not materially differing from *A. p. albicauda.* The swollen basal portion of the penis is less than half the total length. The penial retractor is less than one millimeter long.

Ashmunella fissidens Pils.
Proc. A. N. S. Phila., 1905, p. 243.

This species was described from "dead" and discolored specimens, thought to be from Cave Creek Canyon, collected by one of us (Mr. Ferriss) in the course of a flying trip through the mountains in the winter of 1904. In 1906 we collected extensively in Cave Creek; a year later Messrs. Ferriss and Daniels did additional work there, but nothing was seen of *A. fissidens.* The location of the type colony, therefore, remains uncertain. It is likely that the shells were picked up in White Tail Canyon, also hurriedly traversed in 1904. While the prevalent form in White Tail differs from *fissidens* in several respects, yet near the head of the canyon some exactly similar shells were found by us in 1906. A lot from near the head of the left branch (going up) (near Jim Artel's old camp) is typical *fissidens*; and we suggest that this be regarded as the type locality in case true *fissidens* is not hereafter found in Cave Creek.

In these shells the lip is not produced forward in an angle near the upper insertion, and the upper angle is not filled with a callus; the lip is narrow with rounded face; there is no upper branch developed on the parietal wall, unless very weakly in some old shells; there are fully 6 whorls; the young develop only a weak lip-rib at resting stages.

Certain forms from much further south, in Shake Gulch, the foot of Bonito Canyon and Limestone Mountain, seem to be referable to *A. fissidens*; but they are less angular, becoming rounded behind the lip, and the umbilicus is decidedly smaller. More material is needed to fix their status.

Ashmunella fissidens albicauda n. subsp. Fig. 19.

The upper end of the parietal wall stands more or less free and the lip, near its upper insertion, runs forward in an angle; the posterior angle of the aperture is heavily calloused, and the parietal tooth is usually V-shaped by development of a weak upper branch. The young shells form a very thick and heavy callus within the lip at resting stages (fig. 19D).

Adult shells are invariably acutely angular in front, the angle weakening and almost disappearing on the latter part of the whorl. Behind the aperture the striation is stronger and sometimes amounts to an irregular costulation. There is an angular gutter behind the basal lip, and the reddish-brown color gives place there to a wide buff stripe which borders the lip. The whole base has a sculpture of extremely minute *spiral lines* in fresh examples; and under the microscope a very minute spiral lineolation is seen between these spiral lines, which are readily visible with a hand lens. The upper surface also shows very faint spiral lines in places, and there is often some interruption of the growth striæ, giving a slight appearance of punctation. Seven specimens from Station 14 measure:

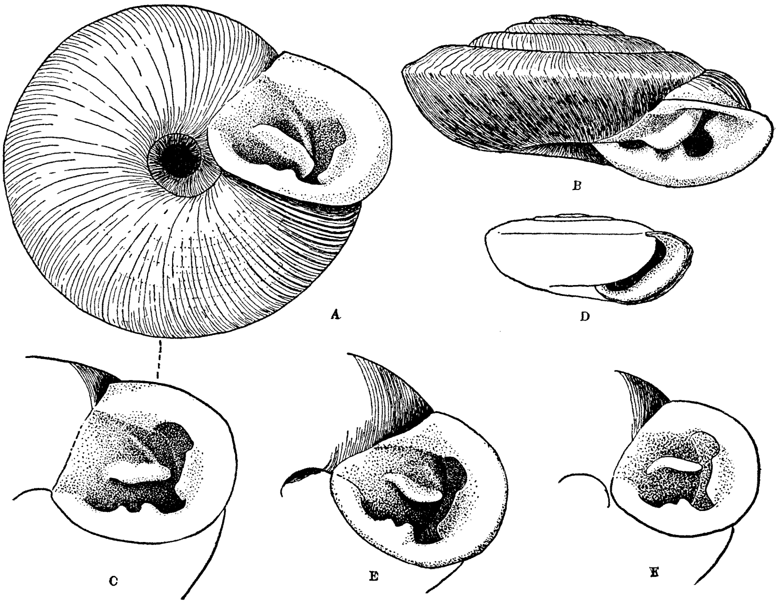


Fig. 19.—*Ashmunella f. albicauda* P. and F. A–C, from Box of White Tail (diam. 13.3 mm.); D, Station 14 (diam. 7 mm.); E, Station 2 (diam. 12 mm.); F, Station 14.

Alt	5	5.5	4.8	4.7	5.2	4.8	5	mm.
Diam	12.5	12.5	12	11.5	11.5	11.3	11.3	"
Whorls	5½	5½	5½	5½	5½	5½	5½	

While variable in size and elevation of the spire, which may be nearly flat or low-conic, and in the shape of the basal teeth, the variations do not seem to differ in the several colonies.

Terminal ducts of the genitalia are figured on p. 95, fig. 16, and the measurements are given in the table, p. 97. The epiphallus in the individual measured (No. 97,939, Station 4, in White Tail Canyon) is shorter than in *A. p. emigrans* or *A. duplicidens*, but this may be an individual character.

A. f. albicauda is found in White Tail Canyon almost everywhere *on the southern side,* but not on the opposite slope of the canyon. Specimens were taken at Stations 1 to 5, 9, 12, 14, on the south side of the Box Canyon and on the south side below Indian Creek, ranging from about 20 feet above the creek bed (at the last place) to about 7,500 feet elevation on the rim southward, where indeed it was taken at Station 3, which lies across the acute divide and on the Pinery side. Not one single specimen was found on the north side of the canyon, where *A. lepiderma* replaces it, coming down to the bottom of the canyon.

The range of *A. fissidens* in the Pinery and Pinery Canyon is unknown. The great Pinery Valley lay before us in splendid panorama from the ridge south of White Tail Canyon and again from the ridge north of Barfoot Park. Probably its ravines are inhabited by *fissidens* and perhaps forms connecting that with *A. proxima.* It may be noted that the large *Sonorella* of White Tail Canyon is a race of *S. virilis*, of Barfoot Park, etc.

At all stations in White Tail Canyon where many shells were taken, the same variations in height of spire noted under *A. duplicidens* were noticed. Otherwise there is variation in the size of the outer lip-tooth and especially in that of the inner tubercle of the basal tooth. The parietal tooth may be either straight at its axial end or abruptly curved inward, and, when turned inward, a low ridge usually runs to the outer end of the lip, making the parietal tooth V-shaped.

Ashmunella fissidens pomeroyi n. subsp. Fig. 20.

In Hand's Pass, head of Jhu Canyon, Ferriss and Pomeroy collected

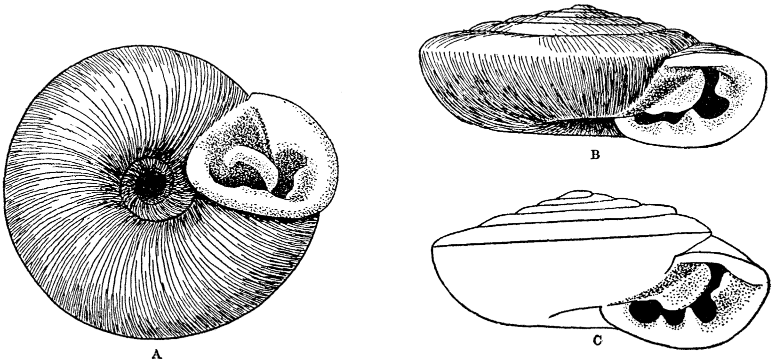


Fig. 20.—*Ashmunella f. pomeroyi* P. and F., Hand's Pass.

in 1908. The shells are similar to those of White Tail Canyon in general appearance, but differ in certain particulars, constituting a minor race. They are in the average smaller, diam. 8½ to 11½ mm., rarely 13 mm., with 5½ whorls; the umbilicus is noticeably wider; the lip is heavy and wide. The basal teeth vary from completely united to distinctly bifid, as in White Tail *fissidens*, or rarely they are almost separated. In most examples these teeth are more united than in White Tail specimens. The shape of the parietal tooth also varies from V-shaped to simple. All of the shells are more angular and more depressed than *A. duplicidens.*

Ashmunella duplicidens Pils. Pl. VIII, figs. 1–8.

Proc. A. N. S. Phila. 1905, p. 244.

After the first 1½ whorls the next four whorls more or less appear minutely punctate in the best preserved examples, though in most only an indistinctly interrupted condition of the striæ can be made out. Under the compound microscope some very fine close spiral striation is seen on the base. The basal tooth is ordinarily doubled as in figs 5 and 8; but sometimes is simple, the inner tubercle being represented only by a sloping callus, as in figs. 1–3, 6, 17.

Immature shells form only a thin narrow rib within the lip at resting stages, and have a wider, somewhat less angular, aperture than *A. fissidens*. This thin lip-rib is subsequently wholly, or almost wholly, absorbed, so that adult shells do not show whitish varix-streaks.

Figs. 3 and 7 show the extremes of elevation and depression of the spire. All of these figures are from topotypes, from Station 1 in Barfoot Park—an extensive slide of coarse rock on a southern exposure. It is an abundant species in this place.

In 1907 Mr. Ferriss found *A. duplicidens* in the head of Morse Canyon, large shells, 13 to 14 mm. diam., with over 6 whorls; in Rucker Canyon, 7,000 to 8,000 feet; and on Rucker Peak, where they are also rather large. Small shells, 10.5 to 11.5 mm. diam., were taken at the Box of Rucker. A specimen from Crook's Peak measures 14 mm. diam.

Large and well-developed *duplicidens* was found in Cave Creek Canyon on the first branch west of the Falls fork of Cave Creek, diam. 14 to 15 mm., and at the Falls.

The genitalia of a specimen from the head of Morse Canyon are figured, pl. X, fig. 8. The penis tapers more gradually than in allied forms, the distinction between its swollen basal half and the slender distal portion being obscure. This was also the case in the individual figured in 1905 from the type lot, but in that preparation the enlarged basal portion of the penis was everted, hence does not show at all in the figure. The lung is 18 mm. long, kidney 7.5 mm., pericardium 3.5 mm. The mantle within the last whorl is cream-colored with sparse black maculation. Earlier whorls have copious black pigmentation along the top of the whorls.

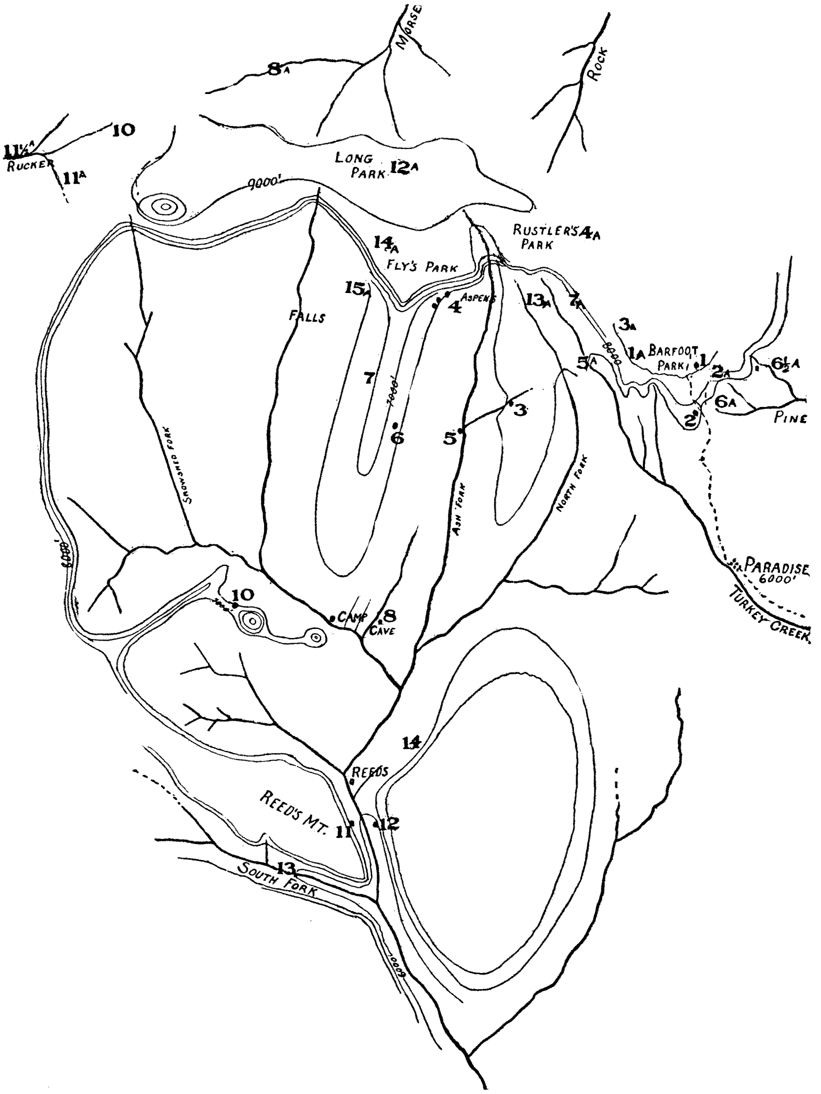


Fig. 21.—Principal collecting stations in Cave Creek and the Parks at its head. Stations marked A were explored in 1907–8 by Ferriss, the others in 1906 by Ferriss and Pilsbry.

The specimens figured (topotypes) measure: Alt. 6, diam. 13 mm., whorls 6¾; alt. 6, diam. 12.2 mm., whorls 6½. The smallest specimen seen is from Rucker Canyon, 7,000 feet, measuring alt. 4.9, diam. 10.5 mm., whorls 5½.

A. duplicidens stands very close to *A. fissidens*, but it differs by the more obtuse, though bluntly angular, last whorl, and by the young shells, which form only a very thin, narrow rib within the lip in resting stages, while in *fissidens* a very strong and heavy callus is deposited. The basal teeth are more united than in typical *fissidens.*

A. duplicidens, fissidens and *proxima* are terms of one series of forms differing chiefly, so far as the adult shells are concerned, in the degree of separation of the basal tooth, which in *duplicidens* is a single more or less bifid prominence, while in *proxima* there are two distinct teeth. When the canyons opening westward, between Rucker and Ft. Bowie, have supplied series of shells as copious as those we have obtained in the eastward canyons, another chapter may be added to the history of this group.

Ashmunella angulata Pils.

Proc. A. N. S. Phila., 1905, p. 244.

In the south fork of Cave Creek we found this species abundantly. This is the type locality and here it attains the largest size. A few dead ones were picked up on a mountain-side southeast of Paradise, towards Cave Creek, and at Station 12, in Cave Creek. It reappears at the head of the canyon at the Falls, and at Stations 3 and 4 and in the head of Turkey Creek. At these places the shells are smaller.

In 1907 Ferriss and Daniels took some specimens in Barfoot Park, Station 1*a*. They are much less angular at the periphery than the Cave Creek form. In 1908 it was taken in Horseshoe Canyon at the "Red Box" (10 miles up the canyon) and at "5-mile camp"; also in Rock Creek, at the head of Raspberry Gulch and in the Spring Branch of Rucker Canyon. These localities greatly extend the range of the species. The compressed outer basal tooth and less convex whorls readily separate *A. angulata* from *A. proxima.* Young shells deposit a lip-callus at resting periods. It is thick in the middle, tapering at the ends, as figured in our former paper, pl. XI, fig. 11.

Our former figure of the genitalia of *A. angulata* (1905, pl. 21, fig. 26) is not satisfactory in one point, the slight enlargement marking the upper end of the penis being omitted. This enlargement is rather small yet distinct in the individual figured, which has been re-examined, and is present in all the specimens opened (seven) from several stations.

A new figure is given, pl. X, fig. 6, representing a specimen from Cave Creek near Reed's Mountain, No. 87,020. The penial retractor muscle is longer than in *A. proxima* and its allies.

Ashmunella ferrissi Pils. Fig. 22.

A. ferrissi Pils. Proc. A. N. S. Phila., 1905, p. 247, pl. 16, figs. 108–110, 113.

The type locality is in the talus at the foot of Reed's Mountain, at Station 11, about a half mile below Reed's house, where it is found with *A. chiricahuana, Sonorella virilis,* etc. Additional specimens were taken here in 1906. The figures represent an elevated and a depressed specimen.

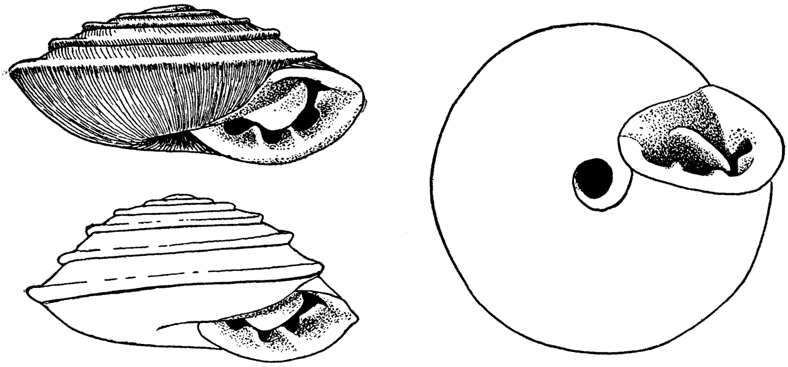


Fig. 22.—*Ashmunella ferrissi*, Cave Creek, Station 11 (topotypes).

The embryonic shell seems to comprise the first 1¾ whorls. The initial half whorl is smooth and glossy; then growth-striæ begin below the suture, gradually extending over the whole width of the whorl. The third and fourth whorls are very minutely indistinctly marked with subregularly arranged points, as though hairy in the immature stage, though none taken retain any hairs. The rest of the whorls are finely striate. The base also is marked with very fine, unequal growth-striæ, and under a strong lens shows faint, extremely fine and close spiral striæ. These are also faintly visible in places on the upper surface. The carina first appears above the suture at the end of the second whorl in some examples, in others at the end of the third.

There is considerable variation in size and degree of elevation. Three of the specimens taken in 1906 at the type locality measure:

Alt. 6.2, diam. 12.5 mm.
" 5.2, " 11.8 "
" 5.6, " 10.6 "

The punctation of the early neanic whorls, not noticed when the species was first described, shows that *A. ferrissi* is related to *A. angulata,* a much more widely spread species.

Genitalia as usual in the group. Basal half of the penis is swollen. As in *A. angulata,* the retractor muscle of the penis is longer than in *A. duplicidens, proxima,* etc. The mantle within the last whorl is white (pl. X, fig. 7).

Group of Ashmunella chiricahuana.

This group is distinguished by the very long spermatheca and epiphallus and the open aperture, which is either toothless or provided with minute vestigeal teeth which do not sensibly obstruct the opening.

A. chiricahuana has never been found to have any trace of teeth. It varies in size and degree of elevation of the aperture. *A. esuritor* frequently retains minute vestiges of teeth, but they are variable and often hardly noticeable. It is less evolved than *A. chiricahuana* in retaining this functionless reminiscence of the toothed ancestral form. The series is exactly parallel to the *A. levettei-varicifera* series in the Huachucas, but there the degeneration of teeth has been more recent and all stages of the process still exist.

Ashmunella chiricahuana (Dall). Fig. 23.

Proc. A. N. S. Phila., 1905, p. 250.

This fine *Ashmunella* is widely distributed in Cave Creek Canyon, living on reasonably moist north slopes where there is good rock shelter, with *Sonorella.* In 1906 we took specimens at Stations 3, 4, 5, 11, and in the ravines west of Reed's Mountain between that and Station 10. In 1907 and 1908 the following localities were added by Mr. Ferriss: Cave Creek Falls, head of Cave Creek near Long Park, Long Park at 8,000 feet. The types were from the adjacent Fly's Park (No. 124,481 U. S. N. M.). The figures published by Dr. Dall represent *A. varicifera,* a Huachucan species, and we have therefore given new illustrations.

The color varies from light brownish-corneous to light chestnut, and occasionally albinos are found. The surface is very glossy. Young specimens form a strong wide white rib within the lip when a resting stage occurs. This persists as a yellow blotch or stripe in the adult stage.

Some specimens, as those from Cave Creek, Station 5, and the head of Cave Creek, show traces of punctation on the intermediate whorls not visible in most others.

The chief variation, aside from tint, is in the elevation of the spire.

Two examples, extremes of a continuous series, are figured to illustrate this (fig. 23 *c, d*), from about the middle of the amphitheatre west of Reed's Mountain. This variation is not peculiar to any special colonies, though greater in some lots than others.

At the Cave Creek Falls there is a small form. Three specimens measure as follows:

Alt.	8	7	6.7 mm.
Diam.	16	16	13.5 "
Whorls	5½	5⅔	5⅓

The genitalia of two individuals are figured. Pl. X, fig. 4, is from one of the very large shells of the head of Cave Creek at about 8,000 feet elevation, near Long Park, diam. 19.5 mm. The ducts are very long in these large snails. Both penis and spermatheca adhere to the uterus throughout part of their length, the penis looping under the spermatheca. The vagina is stout down to its base. Pl. X, fig. 1, was drawn from one of the very small shells of the Cave Creek Falls, diam. 13.5 to 16 mm. The ducts are shorter and the base of the vagina is thin-walled. The penial retractor is longer in this species than in the toothed species, but not so long as in the Huachucan Ashmunellas.

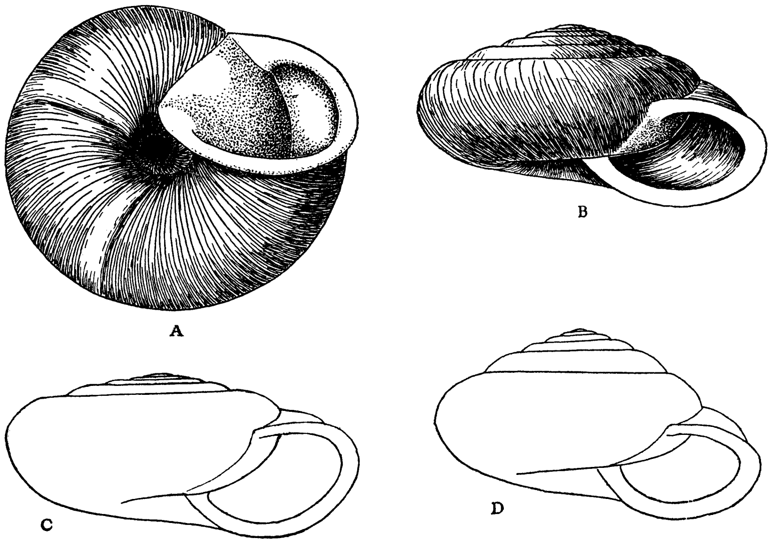


Fig. 23.—*A. chiricahuana* (Dall). A, B, Cave Creek Canyon; C, D, amphitheatre of Cave Creek.

The collar and foot are slate-colored; mantle-lining of the last whorl cream-white, not maculate.

In a former paper[21] we mentioned a form of *Ashmunella* from Miller Canyon, Huachucas, which, so far as the shell is concerned, agrees exactly with *A. chiricahuana.*

Specimens collected in 1907 have now been dissected. The Huachucan form proves to be practically identical with *A. levettei* in the soft anatomy, and abundantly distinct from *A. chiricahuana* in the proportions of the organs, especially of the spermatheca and its duct, as will be seen by the following table:

	A. chiricahuana, Chiricahua Mts.	Huachuca Mt. form.
Length of vagina	9 mm.	7.2 mm.
" " spermatheca and duct	56 "	26 "
" " penis	4.5 "	7.3 "
" " epiphallus and flagellum	68.5 "	40 "

The spermatheca in the Huachucan form has the long, cylindric, weakly sacculate shape of that of *A. levettei,* wholly unlike that of *A. chiricahuana.* This form has been fully described and figured in a former paper. It is undoubtedly the shell indicated as *A. chiricahuana* var. *varicifera* Ancey, and will now be called *Ashmunella varicifera.*

Ashmunella esuritor Pils. Pl. IX, figs. 1–8.

Proc. A. N. S. Phila., 1905, p. 249, pl. 13, figs. 23–26 (shell); pl. 21, figs. 30, 25 (genitalia).

The type locality is not in Barfoot Park proper, but in a small park of yellow pine on the road from Paradise, about a mile before it crosses the ridge or divide going to Barfoot. This is the first grove of yellow pine on the road up. The type locality is a small conical pile of earth and rocks about ten feet to the left of the road.[22] It was covered with snow at the time of our visit, but a small series of living specimens was taken, No. 92,205 A. N. S. P. About a mile below this place, toward Paradise, where a few yellow pines first appear among the oak scrub, we found a few examples. It will probably be found in many other suitable places in this immediate vicinity, reached by the road from Paradise to Barfoot Park. Our work in this place was impeded by a heavy snowfall, which lay knee-deep among the pines.

In the topotypes (No. 92,205) the diameter varies from 14.5 to 16 mm., whorls 6 to 6½. The degree of elevation of the spire is quite variable, as in all the related species. Two of this lot are figured, pl. IX, figs. 1, 2, 4, 5. In one or two shells there is the minute vestige of a parietal tooth (figs. 4, 5). The soft parts were partially spoiled when studied, but I have figured the terminal ducts of the genitalia, pl. X, fig. 3. The spermatheca was broken. Other organs agree with the type figured in 1905.

---

[21] Mollusca of the Southwestern States I, *Proc. A. N. S. Phila.,* 1905, pp. 242, 251, pl. XV, figs. 94, 95.

[22] We would ask future collectors to preserve this small type colony by taking only a moderate number of specimens there.

The genitalia of two specimens are figured, pl. X, figs. 2, 5. The penis and vagina conform in shape to the usual Chiricahuan type. The retractor muscle of the penis is well-developed, but short, about 2 mm. long. The epiphallus is very long. Measurements of the organs may be found on p. 97. The penis and epiphallus are decidedly longer in three specimens of this lot dissected than in the type or topotype of *esuritor*. The spermatheca of the types of *esuritor* is unusually swollen distally, as correctly represented in the figure published in 1905.

Additional specimens (pl. IX, figs. 6, 7, 8) from the east side of Barfoot Park, Station 1*a*, were taken by Mr. Ferriss in 1907. The penultimate and two preceding whorls have the fine striæ interrupted irregularly, in places forming minute granules, and there is besides some indistinct appearance of punctation on the spire. There are very fine spiral lines on the base. There is a wide prominence, hardly to be called a tooth, within the outer lip in most examples, but in some this is very low or wanting, and in none quite so prominent as in the type of *A. metamorphosa*. Edentulous specimens resemble *A. chiricahuana* closely, but they differ from that species by the slightly more depressed shape, by having a rather deep, narrow gutter behind the lip (almost wanting in *A. chiricahuana*), by the smaller aperture in shells of the same diameter, and by having the umbilicus wider within, though not at its mouth. Three adults, No. 94,432, measure:

Alt.	8	7.3	6.7 mm.
Diam.	17	16.3	15 "
Whorls	6½	5¾	6

In 1906 we dug out a small series of dead shells (No. 97,930) from under the snow and rocks in the head of Pine Canyon,[23] perhaps fifteen minutes walk down from Barfoot Park. The callous "tooth" within the outer lip is either weak or wanting in these examples, and four out of ten adults taken show the weak trace of a parietal tooth. The most elevated shell of this lot is drawn in pl. IX, fig. 3, Alt. 9, diam. 17 mm., with 6½ whorls.

---

[23] This canyon, which runs westward from Barfoot Park, is sometimes called Riggs' Canyon, or Saw-mill Canyon. At its head a saw-mill stood, but it was removed in the spring of 1907.

The specimens measure:

Alt	8.3	7	8	9	7.5	mm.
Diam.	17.2	17	16.5	17	16	"
Whorls	6	6¼	6¼	6½	....	
Alt	8	7.5	8	7.5	7	mm.
Diam	16.4	16.5	16	15.5	15	"
Whorls	6	6⅓	6½	6	5¾	

A single shell from Onion Creek has a distinct callous prominence within the outer lip and a low tooth in the basal lip. Anatomically it resembles the topotypes of *A. esuritor* so far as can be made out, the soft parts being mutilated in pulling. The mantle is white within the last whorl.

Group of A. metamorphosa.

Ashmunella metamorphosa Pils. Pl. IX, fig. 9.

Proc. A. N. S. Phila., 1905, p. 252, pl. 16, fig. 115 (shell); pl. 22, fig. 8 (radula); pl. 23, fig. 16 (jaw); pl. 21, fig. 27 (genitalia).

With one exception the original figures of this species, cited above, were taken from one specimen. Fig. 114 of plate XVI (1905) represents another shell, probably not conspecific. It is now proposed to restrict the type of *A. metamorphosa* to the broken shell represented on pl. XVI, fig. 115, the anatomy of which was figured. This is No. 88885 A. N. S. P.

This shell (pl. IX, fig. 9) resembles *A. esuritor* in contour. There is a deep furrow behind the narrowly reflexed basal·and outer lips. The outer lip bears a long low callus on its inner edge. Above this callus it is brown, elsewhere white. Whorls 6. The surface is not well preserved and shows no minute sculpture, being somewhat worn. Alt. 8.8, diam. probably about 17 mm. It is a fully adult, but not old, individual. In pl. IX, fig. 9, the aperture of the type specimen of *A. metamorphosa* is drawn, the former photographic figure being unsatisfactory.

Barfoot Park, collected by James H. Ferriss, February, 1904.

We have nothing to add to the description and figures of genitalia jaw and teeth given in 1905. Having again examined the genitalia of the type, we see nothing to indicate that it is abnormal. The possibility that it is the ♀ phase of a proterandrous form has been considered, but the absence of such a condition in the other species of the genus makes against such hypothesis. If normal, the genitalia of this snail indicate one of the most distinct Chiricahuan species, a penis and its retractor being absent, as in some slugs.

The lot originally referred to this species consisted of three specimens, two being included in Mus. No. 88,886. The soft parts of one of these were mutilated and not preserved. The other one has been dissected and proves to be *A. esuritor.* When we were in Barfoot Park near the end of November, 1906, snow lay almost knee-deep among the big pine trees and living snails were hard to find. Some dead shells (No. 97,930), taken in the head of Pine Canyon, may be *metamorphosa,* but we refer them for the present to *A. esuritor.* No shells known to have the anatomical peculiarities of *A. metamorphosa* have been taken since 1904.

We have found no character in the shell to certainly distinguish *A. metamorphosa* from *A. esuritor.* The latter varies from forms with a nearly simple lip, like *A. chiricahuana,* to those with various callous vestiges of teeth, as shown on the plate, figures 1 to 8. Further collections of specimens in the flesh are needed.

Thysanophora hornii (Gabb).

Helix hornii Gabb, Amer. jour. of Conch., II, 1866, p. 330, pl. 21, fig. 5 (bad).
Thysanophora hornii Gabb, Pilsbry, Nautilus XI, 1898, p. 105; XIII, Jan., 1900, p. 98; Proc. A. N. S. Phila., 1903, p. 763; 1896, p. 126; Hinkley, Nautilus XXI, 1907, p. 172 (Tampico); Dall, Proc. U. S. Nat. Mus., XIX, 1896, p. 336.
Not *Patula horni* Gabb, W. G. Binney, Man. Amer. Land Shells, Bull. 28, U. S. N. M., 1885, p. 169.

Chiricahua Mountains: near Dos Cabezas cave; near Lawhorn's ranch, mouth of Big Emigrant Canyon; White Tail Canyon above Stations 4 and 11, rare; Cave Creek Canyon on the slope below the cave, at Station 6, and about a half mile up the South Fork.

Thysanophora ingersolli (Bland). Fig. 24, A, B, C.

Helix ingersolli Bland, Ann. Lyc. Nat. Hist. of New York, XI, 1874. p. 151, figs.
Microphysa ingersolli Bld., W. G. Binney, Terr. Moll., V, p. 173, fig. 82 (shell); pl. III, fig. V (teeth); Man. Amer. Land Shells, 1885, p. 170, fig. 160.
Thysanophora ingersolli Bld., Dall, Proc. U. S. N. Mus., XIX, p. 366 (Fly Park); Pilsbry, Nautilus XI, p. 105; J. Henderson, The Mollusca of Colorado, Univ. of Colo. Studies IV, No. 3, p. 169.

This species differs from the typical forms of *Thysanophora* by the absence of cuticular laminæ or hairs, the surface being clean and bright, with the appearance of a *Vitrea.* Under very high magnification some spiral striæ are visible on the intermediate whorls, but not on the first. In the typical form, the aperture is narrowly lunate, the spire almost flat, umbilicus nearly one-fourth of the diameter, "Height 2.5, diam. 4 mm." In many Colorado examples the umbilicus is narrower, about one-fifth the diameter of the shell.

The localities for *T. ingersolli* in Colorado have been given by Henderson (*l.c.*). Specimens are in coll. A. N. S. from Field, British Columbia (Stew. Brown). In New Mexico we have seen it from Sapello Canyon at Beulah (Cockerell); Sandia Mountains near Albuquerque (Miss Maud Ellis); Bland (Ashmun); James Canyon, Cloudcroft, Sacramento Mountains (Rehn and Viereck). In Arizona we have it from Bill Williams Mountain near Williams (Ferriss and Pilsbry) and the top of Mt. Mingus, near Jerome (Ashmun). A specimen from this place is drawn in figs. 23, *a*, *b*, *c*, alt. 2, diam. 4.4, width of umbilicus 1.15 mm., whorls 5¼. It does not occur in the Chiricahua Mountains.

Thysanophora ingersolli meridionalis n. subsp. Fig. 24, D, E, F.

Shell with a wider aperture than *T. ingersolli*; whorls not quite as closely coiled, scarcely 5 in a shell of over 5 mm. diam.; umbilicus about one-fourth the total diameter; spire nearly flat. Alt. 2.3, diam. 5.2, width of umbilicus 1.3 mm., whorls 4¾.

Chiricahua Mountains in Bear Park, Long Park, head of Cave Creek,

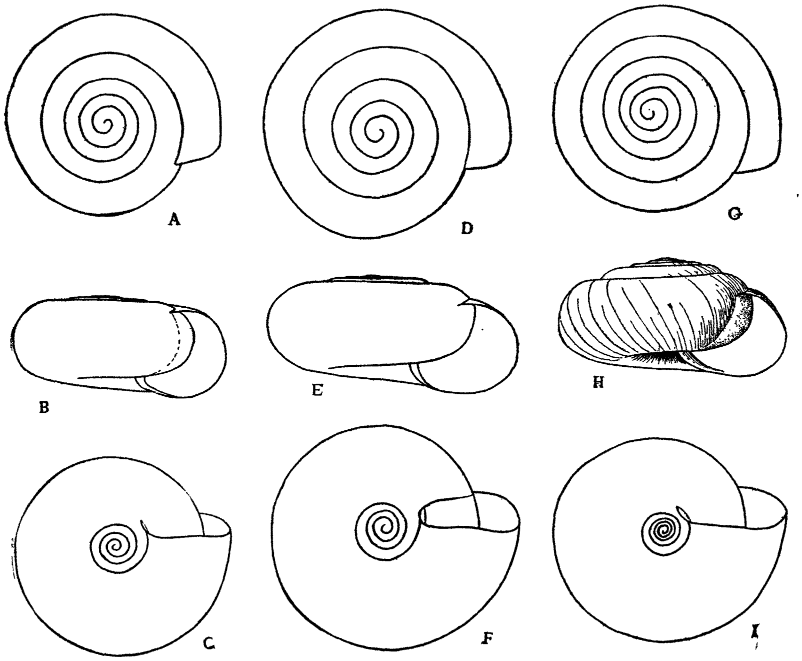


Fig. 24.—A, B, C, *Thysanophora ingersolli* (Bld.), Mt. Mingus, near Jerome, Arizona; D, E, F, *T. i. meridionalis* P. and F., Long Park, Chiricahua Mountains, Arizona; G, H, I, *T. i. convexior* (Anc.), Weston, Oregon.

8,000 feet, Pine Canyon, 7,500 feet, and "Box" of Rucker Canyon. It has been listed by Dall from Fly's Park.

While not strongly differentiated, adult shells of this race are readily distinguishable. The aperture clasps the preceding whorl less deeply than in *ingersolli*. The microscopic spiral striation also is somewhat better developed in the examples compared.

Thysanophora ingersolli convexior (Ancey). Fig. 24, G, H, I.

Microphysa ingersolli var. *convexior* Ancey, Conchol. Exch. II, p. 64, Nov., 1887 (Logan Canyon, Utah).

"Shell a little smaller; spire scarcely planulate, the apex not subimmersed, distinctly convex; whorls 5, not 5½, regularly but less slowly increasing, umbilicus smaller" (Ancey).

This form has not been figured. We have seen no topotypes, but examples from Weston, in eastern Oregon, collected by Henry Hemphill, evidently belong to the same race. One of these is figured (fig. 24, *g*, *h*, *i*). The specimen figured measures, alt. 2.5, diam 4.8, width of umbilicus 1 mm., whorls 5¾. The aperture is a little wider than in typical *ingersolli.*

Family UROCOPTIDÆ Pils.

Genus HOLOSPIRA von Martens.

All of the Holospiras now known from Arizona belong to a single group of closely related species, characterized by the light brown shell, having a stout lamella on the axis in the penultimate and first part of the last whorl, often in addition a superior or parietal lamella, and sometimes a basal lamella also. In several of the forms the lamellæ vary from one to three, as we have demonstrated by cutting from twenty to fifty individuals of a single colony. In colonies so varying, the number of internal lamellæ is not correllated with age, size or any other external feature of the shells, so far as we can discover, after collecting and examining hundreds of shells from a great number of colonies. The subgeneric divisions (*Eudistemma*, *Tristemma*) based upon the number of internal lamellæ in shells of this type have, therefore, no basis in nature. While the Arizona species differ somewhat from the Mexican type of the subgenus *Bostrichocentrum* in texture and sculpture, it does not seem that the differences are of subgeneric importance, and for the present we will place them in that group.

The variations in the internal lamellæ recorded below are really less discontinuous than might be supposed by the tables. The axial lamella is invariably present, but it varies in strength and length. The superior lamella may be very strong and over a half whorl long, but in other individuals of the same colony it may be small or barely observable, so that the series from a strong lamella to none is practically a continuous one in some colonies, though usually this lamella is either distinctly developed or wholly wanting. The same statement applies to the basal lamella, except that it is never very large and usually quite small and short when present.

The study of these races is extremely complex, and we have been unable to find time to enter upon it seriously. Any full record of a form should take into account the number of ribs on a whorl or their distance apart, as well as the proportions of the shell, number of whorls, length of cone, and the lamellæ.

(*a*) In many colonies a longer and a shorter form may be selected, with only few intergrading specimens; and there may also be a noticeable difference in sculpture. Such colonies may perhaps be hybrid, composed of two incipient races. (*b*) Different colonies in the same district, often living under apparently identical conditions, and frequently in close proximity, may show differences in size, ribbing or comparative frequency of certain combinations of lamellæ, in fact, incipient racial divergence. The mingling of two or more such colonies by their spread, aided by changing conditions of surface, may have given rise to colonies of the (*a*) type.

In some cases, where the colonies are widely separated, they have apparently evolved into reasonably distinct subspecies, probably in the absence of intermigration. The Cave Creek colonies of *H. chiricahuana* illustrate this.

Holospira arizonensis Stearns. Pl. XI, figs. 1-4.

H. arizonensis Stearns, Proc. U. S. Nat. Mus., XIII, 1890, p. 208, pl. 15, figs. 2, 3 (Cave at Dos Cabezas). Bartsch, Proc. U. S. Nat. Mus., Vol. 31, 1906, p. 134.

This species has hitherto been known by fourteen fragments and one perfect specimen, the type No. 104,392 U. S. N. M. It measures, length 12.8, diam. at 10th whorl 4.2 mm., whorls 12. We did not visit Dos Cabezas Cave, but our guide and driver, Mort Wien, passed there and collected a series of shells from close to, almost in, the mouth of the cave.[24] Fresh shells are pale corneous brown, glossy, bluish and subtransparent in places on the intermediate whorls. First 2½ whorls smooth; following 6 whorls sharply striate, the striation gradually disappearing, so that two or three whorls preceding the last are smoothish. The last whorl is dull, coarsely striate, its outer wall flattened and tapering to the base, which is a little gibbous and rounded. Its latter part is straightened and runs forward shortly beyond the preceding whorl, the upper wall descending slightly. Otherwise it is not noticeably contracted behind the aperture. The outer lip is narrowly expanded and revolute, and is lined within with a rather thin white callus.

---

[24] It is stated that Mr. Vernon Bailey collected the types in the cave. They had doubtless been carried there by wind or mice. This accounts for the broken condition of all but one specimen of the type lot. No Arizonian *Holospira* lives in caves or shaded or damp places. They live in dry and sunny situations.

One living specimen in the lot is an albino, pure white with some bluish spots.

The axial lamella is strongly developed; superior lamella variable, but usually strong and extending through the last half of the penultimate whorl. Basal lamella variable, usually wanting, but sometimes strong. Twenty specimens opened give the following data:

Three lamellæ: superior, axial and basal (15%)—

Length 14, diam. 4 mm.; whorls 12½.
“ 14, “ 4 “ “ 12¾.
“ 13.5, “ 4 “ “ 12½.

Two lamellæ: superior and axial (65%)—

Length 14.8, diam. 4 mm.; whorls 13¼.
“ 14.5, “ 4 “ “ 13¼.
“ 14, “ 4 “ “ 12½.
“ 14, “ 3.9 “ “ 12½.
“ 13.9, “ 4 “ “ 12½.
“ 13.6, “ 3.9 “ “ 12¾.
“ 13.3, “ 4 “ “ 12½.
“ 13, “ 4 “ “ 11½.
“ 12, “ 4 “ “ 11½.
“ 12, “ 3.9 “ “ 11½.
“ 12, “ 3.9 “ “ 11½.
“ 11.5, “ 4 “ “ 11½.
“ 11.3, “ 3.9 “ “ 11½.

One lamella: axial (20%)—

Length 12, diam. 3.8 mm.; whorls 11½.
“ 11.8, “ 3.8 “ “ 11½.
“ 11.3, “ 3.8 “ “ 11½.
“ .... “ 4 “ “ .... (spire broken).

The above specimens were taken at random.

Holospira arizonensis emigrans n. subsp. Pl. XI, figs. 5–8.

The shell is in the average more slender than *arizonensis*, with more numerous whorls; striation slightly finer, and often extending weakly upon the smoother lower whorls; the last whorl has a broad contraction behind the lip, preceded by an opaque white, *very coarsely striate,* inflation; base opaque white, projecting more than in the type; callus within the outer lip is very heavy. Color dull corneous brown, like the type.

Head of Big Emigrant Canyon, in the region of piñon pine groves. Type No. 99,701 A. N. S. P. from Station 1; also taken at several stations eastward in the same neighborhood.

The head of Big Emigrant Canyon is cut into numerous small ravines, the northern slopes of which are wooded with piñons. The rock is limestone. Here *Holospira* was found in large numbers. In the type lot 25 specimens, taken wholly at random from a series of some hundreds, were opened and measured.

Three lamellæ: superior, axial and basal (16%)—
Length 13.5, diam. 4 mm.; whorls 13⅓.
“ 13, “ 3.9 “ “ 13½.
“ 12.3, “ 3.9 “ “ 12½.
“ 12, “ 4 “ “ 12⅓.

Two lamellæ: superior and axial (24%)—
Length 13.4, diam. 3.9 mm.; whorls 13½.
“ 13, “ 3.9 “ “ 13⅓.
“ 13, “ 3.9 “ “ 13.
“ 13, “ 3.9 “ “ 13.
“ 12.9, “ 3.8 “ “ 13½.
“ 12.2, “ 4 “ “ 11¾.

One lamella: axial (60%)—
Length 15.1, diam. 3.9 mm.; whorls 16.
“ 13.9, “ 3.9 “ “ 13½.
“ 13.9, “ 3.8 “ “ 14.
“ 13.8, “ 3.8 “ “ 14⅓.
“ 13.5, “ 3.9 “ “ 13⅓.
“ 13.1, “ 3.9 “ “ 13½.
“ 13, “ 3.9 “ “ 13⅓.
“ 13, “ 4 “ “ 12¾.
“ 13, “ 3.8 “ “ 13⅓.
“ 12.5, “ 3.8 “ “ 12¾.
“ 12.4, “ 4 “ “ 12¾.
“ 12.3, “ 3.6 “ “ 13.
“ 12, “ 3.9 “ “ 12¾.
“ 11.9, “ 3.3 “ “ 12½.
“ 11, “ 3.9 “ “ 11½.

The smallest individual in the lot measures, length 11, diam. 3.4, whorls 12⅓. It has superior and axial lamellæ.

In another lot from a colony not far from Station 1, in 20 shells opened the proportions are:

Three lamellæ, superior, axial and basal	4 specimens,	20%
Two lamellæ, superior and axial	10 "	50%
One lamella, the axial	6 "	30%

Two other small lots were taken a mile or two southeast from Station 1, the shells resembling the type lot, though perhaps there may be a greater proportion of slender specimens among them.

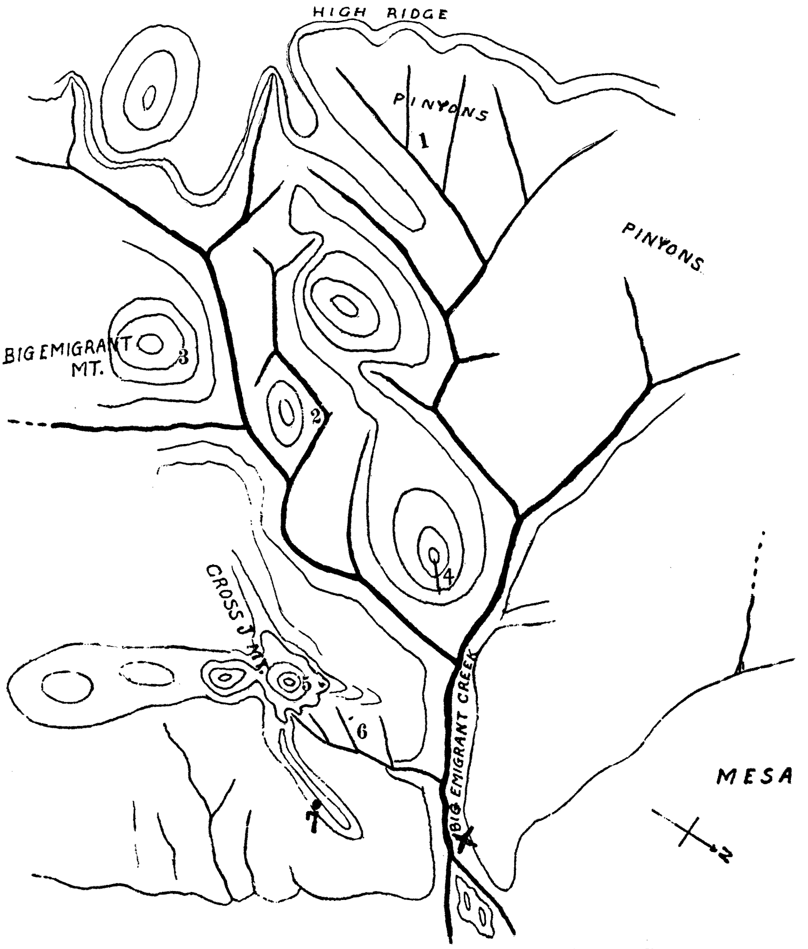


Fig. 25.—Principal collecting stations in Big Emigrant Canyon.

At Station 2, at the bottom of the canyon (middle branch), a few dead specimens sharply, but very finely, striate throughout were found (pl. XI, figs. 9, 10, 11, 12). On the tapering cone and basal whorl the striæ are coarser. At the head of this branch a small series (about 25) of similar shells was found. They are hardly distinguishable from *H. cionella*. *Holospira* colonies are scattered profusely all over the head slopes of Big Emigrant Canyon. We doubt whether more than one specific stock is represented there, though when thoroughly worked several minor races might be mapped out.

Holospira cionella Pils. Pl. XII, figs. 1, 2.

Proc. A. N. S. Phila., 1908, p. 217.

The types of this species came from near Old Fort Bowie. The fort stands on the narrow and low neck which unites the Dos Cabezas range with the Chiricahuas proper. Only the adobe walls now stand; only the cemetery remains to be guarded! The ridge has here a minimum elevation of 5,500 feet. About a mile south Mr. Dixon's place lies in the valley east of two conical peaks, known as Bull Hill and Quartzite Peak, the former of cherty limestone formation. *Holospira cionella* is found on the slope of Bull Hill facing the fort, the exact spot being along a tiny gully which crosses the trail to the fort. This place is indicated on the right at (3) in the photograph reproduced on page 67. It probably has an elevation of 6,000 to 6,200 feet. Another colony is on the lower slope of Quartzite Peak, toward Dixon's house, also indicated in the photograph at (2). Specimens from this place agree most closely with the original types of *cionella*.

The figured types (pl. XII, figs. 1, 2) are cylindric shells, evenly and rather finely but strongly rib striate, the striæ not weaker on the latter whorls; they are coarser on the swelling behind the contraction preceding the lip. Out of 11 shells of the type lot opened, 9 have an axial lamella only; 2 have axial and superior or parietal lamellæ. When originally describing this species only a few specimens were opened, and all happened to have one lamella only. The four specimens figured in 1905 measure as follows (the first three may be considered cotypes):

Length	12,	diam.	3.1	mm.; whorls	12½.
"	11.3,	"	3.25	" "	12.
"	11,	"	3.25	" "	12.
"	8.7,	"	3	" "	11.

Bull Hill (pl. XII, figs. 4–8). Specimens from the locality facing the Fort are all smaller than the types, though a few individuals of the original lot, such as pl. 27, fig. 31, of our former paper, are entirely similar.

Twenty taken at random measure:

Two lamellæ: axial and parietal—
Length 10, diam. 3 mm.; whorls 12.
“ 8.9, “ 3.1 “ “ 11.
“ 8.6, “ 3 “ “ 11.
“ 8.4, “ 3 “ “ 10¾.
“ 7.8, “ 3 “ “ 10⅓.

One lamella, the axial—
Length 9.8, diam. 3 mm.; whorls 11½.
“ 9.5, “ 3.1 “ “ 11⅓.
“ 9.4, “ 3 “ “ 10¾.
“ 9, “ 3.1 “ “ 10½.
“ 9, “ 3 “ “ 11¾.
“ 8.9, “ 3 “ “ 10¾.
“ 8.8, “ 3 “ “ 10¾.
“ 8.8, “ 3 “ “ 10¾.
“ 8.5, “ 3 “ “ 10½.
“ 8.4, “ 3 “ “ 10½.
“ 8.4, “ 3 “ “ 10½.
“ 8, “ 3 “ “ 10½.
“ 8, “ 3 “ “ 10.
“ 7.7, “ 3 “ “ 9½.
“ 7.2, “ 3 “ “ 9½.

Goodwin's Canyon, near Lawhorn's ranch, not far south of Nine-mile Water Hole, is the locality of a small series taken by Mort Wien (pl. XII, fig. 3). They are decidedly wider than Fort Bowie *cionella,* and have either two or three lamellæ in the few examples opened. It is apparently a subordinate race of *cionella.* The largest and smallest measure:

Length 11, diam. 3.5 mm.; whorls 12⅓.
“ 10, “ 3.5 “ “ 11½.

Some specimens of similarly wide shape, but with only the axial lamella, in a few opened, were taken by Mort Wien “a half mile from Dos Cabezas Cave.”

Holospira cionella intermedia n. subsp. Pl. XIII, figs. 1–14.

The head and southern slope of White Tail Canyon are inhabited by a race closely related to *C. cionella,* but remarkably polymorphic. The internal lamellæ vary from one to three, but in most colonies there are one or two, the former number predominating. The sculpture is always coarse on the cone, but on the cylindric part it may be coarse, partially effaced, or fine, in specimens of the same colony, while in some other colonies one or other of these conditions may be developed separately. The White Tail series deserves far more study than we have been able to find time for.

The shell differs from *H. cionella* by the perceptibly longer taper and coarser striation of the terminal cone, and slightly greater development of the basal crest. In the form selected as type (pl. XIII, fig. 3) the ribs continue throughout, but in many examples of the same lot they weaken more or less on the penultimate and next earlier whorls. The callus within the aperture is very heavy.

Type locality on the south side of the "box" of White Tail Canyon. Types (pl. XIII, fig. 3,) No. 99,684 A. N. S. P. It also was taken at Stations 1, 2, 3, 4, 5, 8, 14; most or all of these colonies being of considerable extent, although the gathering in each case was made in a small area. The highest points are at Stations 1, 3 and 8; the lowest in the Box Canyon and between Stations 14 and 13. See map on p. 75. It was taken also in Jhu Canyon, Turkey Creek and Limestone Mountain. All of these stations are on limestone.

There is variation in sculpture in the type colony, some examples being strongly striate throughout, but in most the striæ are weaker on the penult whorl. Pl. XIII, figs. 3, 4 and 5, represent shells from the type colony. Thirty-seven specimens of this lot opened measure:

(Shells with the ribs weak on penultimate whorl.)

One lamella: axial—

Length 13, diam. 3.9 mm.
" 11.9, " 3.7 "
" 11.8, " 3.4 "
" 11.5, " 3.8 "
" 11.1, " 3.2 "
" 11, " 3.6 "
" 11, " 3.6 "
" 11, " 3.4 "
" 10, " 3.3 "
" 10, " 3.25 "

Two lamellæ: axial and superior—

Length 12.1, diam. 3.4 mm.
" 11, " 3.4 "
" 10, " 3.4 "

Three lamellæ: axial, superior and basal—
Length 10, diam. 3.4 mm.

(Shells with strong ribs throughout.)
One lamella: axial—
Length 12, diam. 3.3 mm. (Type specimen, pl. XIII, fig. 3).
“ 11.2, “ 3.1 “
“ 11, “ 3.4 “
“ 11, “ 3.4 “
“ 11, “ 3.4 “
“ 10.6, “ 3.3 “
“ 10.6, “ 3.3 “
“ 10.5, “ 3.5 “
“ 10.5, “ 3.2 “
“ 10.5, “ 3.7 “
“ 10.4, “ 3.2 “
“ 10.3, “ 3.5 “
“ 10.3, “ 3 “
“ 10, “ 3.3 “
“ 10, “ 3.25 “
“ 10, “ 3.2 “
“ 10, “ 3.3 “
“ 9.3, “ 3.5 “

Two lamellæ: axial and superior—
Length 11.7, diam. 3.4 mm.
“ 11, “ 3.4 “
“ 10.7, “ 3.2 “
“ 10, “ 3.5 “
“ 9, “ 3 “ Specimen figured, pl. XIII, fig. 5.

Station 2.—Similar specimens occurred at higher levels at Station 2. A large proportion of these specimens are ribbed throughout. The lamellæ in 15 shells opened are as follows:

10 shells have 1 lamella, the axial.
5 shells have 2 lamellæ, axial and superior.

Station 3.—Shells were taken under stones on the sunny side of the ridge, and another lot on the summit of the ridge. The majority of the shells are ribbed throughout, but some have the penultimate whorl nearly smooth. Most specimens are 10 to 11 mm. long. In 13 opened:

8 shells have 1 lamella, the axial.
5 shells have 2 lamellæ, axial and superior.

Pl. XIII, figs. 1, 2, Station 4, northwest branch of ravine back of Gardner's Mine, about three-quarters of the distance to summit. Some of the shells have the terminal cone slightly shorter than in the types. Sculpture variable, as shown in the figures. Internal lamellæ 1, 2 or 3. In 20 specimens opened:

10 have 1 lamella, the axial.
8 have 2 lamellæ, axial and superior.
2 have 3 lamellæ, axial, superior and basal.

Below Station 5, pl. XIII, figs. 13, 14. The shells are small and ribbed throughout, rarely over 9 mm. long.

Box Canyon.—In the Box Canyon, at two stations, one some distance below Station 5 (pl. XIII, figs. 6, 7, 8), the other at the mouth of Indian Creek, the shells are long and slender, strongly ribbed throughout. Axial and superior lamellæ are present in a few opened.

Length 13, diam. 3.2 mm.; whorls 14.
" 10, " 3.2 " " 11½.

Station 8.—A small series agrees, at least superficially, with those from Station 14, which lies about 800 feet lower.

Station 14.—The shells do not differ much from the type lot. There is a longer and coarsely ribbed and a shorter, more closely ribbed, form. Of the longer form we opened 10 shells, 1 having three, 4 two, and 5 one lamellæ. In seven of the shorter form opened 1 has two lamellæ, 6 have one lamella.

Forms from head of Onion Creek.—Two forms are represented in the small lot examined. Pl. XIII, fig. 9, shows a slender shell with coarse, very widely spaced ribs; length 12, diam 3.3 mm., whorls 12½. It has one lamella, the axial. Pl. XIII, figs. 10, 11, 12, represents the prevalent form, shorter than the preceding, *very finely and closely ribbed* throughout, or the ribs may be weak or subobsolete on the penultimate next preceding whorls. In five opened, only the axial lamella is present.

Length 10.5, diam. 3.5 mm.; whorls 11½.
" 9.5, " 3.3 " " 10¾.

Jhu Canyon.—At the head of Jhu Canyon a gathering consists of two forms, similar to pl. XIII, figs. 9–12, from Onion Creek. The larger form is near typical *intermedia,* but the smaller may represent another race of the White Tail type. The material is not sufficient for a definite decision.

Turkey Creek.—On the right (north) side, about two miles below Paradise (pl. XII, figs. 13, 14, 15, 16), *Holospira* apparently referable to *intermedia* was found in two colonies, very variable in size and sculpture. Internal lamellæ one, two or three.

Limestone Mountain.—Although very widely separated from the range of *intermedia,* the shells do not seem separable from that race. Four are figured, pl. XII, figs. 9, 10, 11, 12.

Holospira cionella capillacea n. subsp. Pl. XIII, figs. 15, 16.

Similar to *intermedia* except that the intermediate whorls are very finely, closely striated; only the axial lamella developed, in a few opened. Length 11.7 to 12, diam. 3.5 mm. White Tail Canyon, Station 10, about half way to the summit of the ridge, below cliffs. This colony is the only one found in igneous rock (rhyolite). *Sonorella micra* and *Ashmunella lepiderma* occur in the same vicinity. *Holospira* was very scarce.

Holospira chiricahuana Pilsbry. Pl. XIV, figs. 5–8.

Proc. A. N. S. Phila., 1905, p. 219, pl. 26, fig. 9; pl. 27, figs. 26–29; p. 215, fig. 4.

The type locality of *H. chiricahuana* is on the steep slopes of a small dry ravine or wash tributary to Cave Creek, below and near the entrance of the cave. The slope faces the south and is composed of very steeply dipping friable calcareous shale and earth formed by its decomposition, with sparse vegetation, agave, sotol and bear grass. Dead shells are scattered in profusion, and the living ones lurk under bunches of dead bear grass, etc. The colony is about one-eighth of a mile long and perhaps 100 yards wide. This is also the type locality of *Oreohelix chiricahuana.* Map on p. 107, Station 8.

A majority of the specimens (82 per cent.) have a superior or parietal lamella from ¼ to ½ of a whorl long, on the roof of the penultimate whorl near its end, above the aperture or on the front side, but in some (18 per cent.) this is wanting. In those of the type lot formerly opened it was absent or very weak, but in others of the type lot, as well as in many topotypes opened, this lamella is more or less strongly developed. The interior of the outer lip is very heavily thickened with a white callus within.

All forms of *H. chiricahuana* thus far found have the shell strongly ribbed throughout, with no tendency to become smoother on the cylindrical portion.

While in the type form of *H. chiricahuana* the internal lamellæ are inconstant, yet in several other colonies localized in various parts of the Cave Creek Valley the lamellæ seem to be constant, so far as we can judge from the limited material taken. It must be remembered that many other colonies doubtless exist.

The additional locality, "Fort Bowie," given in our original account, was evidently due to some mixture of labels or specimens. Thorough search in 1906 showed that it does not occur there. The large specimen represented in pl. XXVII, fig. 26, of our paper of 1905, was probably not from the type locality, but picked up somewhere else in Cave Creek Valley.

Fifty specimens opened, taken at random from a lot of several hundred topotypes, measure as follows:

Two lamellæ: parietal and axial—

Length.	Diam.	Whorls.	Length.	Diam.	Whorls.
10.8	3.1	12⅓	9.2	3	11¾
10.8	3	12⅓	9.2	2.9	11½
10.4	3.1	12⅓	9.1	3	11¾
10.3	3	12	9.1	3	11⅓
10.1	3	12	9.1	3	11½
10	3	12⅓	9	3	11½
10	3	12	9	3	11½
10	3	12	9	3	11½
10	3	11¾	9	3	11½
9.9	3.1	12	9	3	11½
9.9	3	11½	9	3	11½
9.8	3	12	9	3	11⅓
9.8	3	12	9	3	11
9.7	3.1	11½	9	3	11
9.6	3	12	9	3	11
9.5	3.1	11⅓	8.9	3	11
9.5	3	11¾	8.9	3	11
9.5	3	11½	8.7	3	10¾
9.5	3	11½	8.6	2.9	11
9.5	3	11½	8	2.9	10½
9.3	3	11½			

One lamella: the axial—

Length.	Diam.	Whorls.	Length.	Diam.	Whorls.
10.6	3.1	12½	9	3	11
10	3.1	11¾	9	3	10¾
10	3	12	8.9	3	11⅓
9.9	3.1	11½	8.9	2.9	11
9.5	3	12			

Holospira chiricahuana ternaria n. subsp. Pl. XIV. figs. 1–4.

At the end of the penultimate whorl there are usually three internal lamellæ: parietal, axial and basal. Shell usually larger with more whorls, but otherwise as in the type.

Length 12.2, diam. 3.4 mm.; whorls 13⅓.
" 11, " 3.2 " " 12½.
" 11.1, " 3.3 " " 12½.
" 10.3, " 3.1 " " 12⅓.
" 10.8, " 3.1 " " 12½.
" 9.4, " 3.1 " " 11.

Station 6, about half way up the northern slope of a long ridge which projects into Cave Creek Valley from the western border.

Fifty-three specimens were taken from a single small colony. The frozen ground did not encourage a thorough investigation. Out of 20 opened, 17 have three internal lamellæ and three have only one, the axial.

Holospira chiricahuana optima n. subsp. Pl. XIV, figs. 13–15.

The shell is larger and perceptibly more slowly tapering than *H. chiricahuana,* with more whorls, and only one internal lamella, the axial, in 20 specimens opened.

Station 5, at the base of the north slope of the ridge mentioned above, close to the stream, under stones. The larger size of the shells might be thought due to the more humid and shaded situation than that inhabited by the typical form, were it not that *Holospira* prefers hot and arid places and does not exist at all in damp situations. A single colony found. About 75 shells were taken. Thirty-five of them, unselected, measure as follows:

Length.	Diam.	Whorls.	Length.	Diam.	Whorls.
14.3	3.7	14¾	13	3.5	13½
14	4	13¾	13	3.5	12¾
14	3.9	13¾	13	3.3	13½
14	3.7	14½	13	3.3	13½
13.9	3.7	13½	13	3.4	13½
13.9	3.5	13¾	13	3.2	13⅓
13.9	3.3	13¾	12.9	3.6	12¾
13.8	3.6	14	12.8	3.5	13½
13.8	3.3	14½	12.7	3.3	13½
13.6	3.3	14½	12.7	3.3	13
13.5	3.8	14	12.6	3.4	13⅓
13.5	3.5	14	12.5	3.5	13⅓
13.3	3.8	14	12.1	3.25	13
13.3	3.4	14½	12	3.7	12½
13	3.8	13¼	12	3.3	13½
13	3.8	13¼	11.3	3.5	12½
13	3.6	13¾	11.2	3.3	13¼
13	3.5	13			

Holospira chiricahuana gracilis n. subsp. Pl. XIV, figs. 9-12.

The shell is more slender and tapers more slowly than the type, and has more whorls. It is more slender than *H. c. optima.* Only the axial lamella developed in 19 out of 20 specimens opened, the other one having a strong parietal lamella also.

Found at Station 10, on the crest of a narrow ridge, a spur from the south wall of Cave Creek Valley, which terminates in a high conical hill standing not far from the creek. This is the only colony of the species found south of Cave Creek, the others being north of the creek. One colony of small extent.

Thirty specimens measure:

Length.	Diam.	Whorls.	Length.	Diam.	Whorls.
11.7	3.1	14	10.9	3	12¾
11.7	3	14	10.9	3	13
11.5	3	14	10.8	3	13
11.5	3	13½	10.7	3	12½
11.5	3	13½	10.5	3	13¼
11.3	3	13½	10.4	3	13
11.2	3	13½	10.3	3	12½
11.1	3.1	13⅓	10.3	2.9	12½
11.1	3	13⅓	10.2	3	12⅓
11	3	13⅓	10.1	3	12½
11	3	13½	10.1	3	12⅓
11	3	12½	10	3	12⅓
11	3	13	10	3	12
11	2.9	13½	9.9	3	12
10.9	3	13	9.9	2.9	12½

LIMACIDÆ.

Agriolimax hemphilli ashmuni Pils. and Van.

Barfoot and Long Parks. The specimens vary from a pale yellowish-gray to the blackish color of the types.

ZONITIDÆ.

Vitrina alaskana Dall.

Long Park, 8,000 feet; Head of Cave Creek, at about the same elevation; Barfoot Park.

Zonitoides arborea (Say).

Head of Cave Creek, 8,000 feet; Long Park, Station 12 A; Rustler Park; Rucker Canyon. It is not commonly diffused, and seems to be absent in the dryer part of the range.

Zonitoides milium meridionalis P. and F.

Quartzite Peak, near Fort Bowie; head of Cave Creek, 8,000 feet;

Rustler and Long Parks; head of Pine Canyon; Rucker Canyon, 7,000 feet.

Zonitoides minuscula alachuana (Dall).

Barfoot Park; Pine Canyon; Spring in lower Rucker Canyon.

Vitrea indentata umbilicata (Ckll.).

Chiricahua Mountains; Buckeye Canyon, in the Dos Cabezas range; Bull Hill and Quartzite Peak, near Fort Bowie; Big Emigrant Canyon at Stations 1, 2, 3, 5, 6; White Tail Canyon at about all the stations east of Stations 4 and 5, at all elevations; Jhu Canyon; Paradise Canyon, on the right side, below the town; Cave Creek Canyon, Stations 4, 6, 8, 11, 12, 13, 14; Barfoot Park; Long Park; Rustler Park; Rucker Canyon; Horseshoe Canyon. Probably occurs wherever snails live in the Chiricahuas.

Genus EUCONULUS Reinhardt.

The term *Euconulus* was proposed by Reinhardt in 1883 for the typical group of *Conulus*, in which he included *Kaliella*. *Conulus* being preoccupied, Pilsbry in 1900[27] substituted *Euconulus* for the generic group, with *fulvus* as type. Dall, 1905,[28] has given the generic synonymy and references in full. Mr. J. W. Taylor in his monograph of British land shells (1908) has discussed the varieties of *E. fulvus*. His treatment of *E. chersinus* as a variety of *fulvus* was evidently due to the lack of specimens, for the two forms are much less alike than the several small British species of *Hyalinia* which he distinguishes, and in fact are unusually distinct as species go among the small Zonitidæ. One of the European forms is apparently close to *chersinus;* but an intelligible exposition and revision of the *Euconulus* of Europe remains a desideratum. There is no trustworthy record of *Euconulus fulvus* from Japan, though *E. fulvus alaskensis* may naturally be expected to occur in the Kuril Islands, Yesso and Saghalin.

Euconulus fulvus alaskensis (Pils.).

Conulus fulvus alaskensis Pils., Nautilus, XII, February, 1899, p. 116. *Cf.* Dall, Land and Fresh Water Mollusks, Harriman Alaska Exped., 1905, p. 40, and Pilsbry, Nautilus, XXII, 1908, p. 25.

Chiricahua Mountains: White Tail Canyon, high on the northeastern side below the confluence of Indian Creek; Cave Creek Canyon at Stations 3 and 4 near the northeastern rim; Barfoot, Long and Rustler Parks; head of Pine Canyon, 7,500 feet; Box of Rucker Canyon.

---

[27] *Nautilus*, XIV, Nov., 1900, p. 81.

[28] *Harriman Alaska Exped.*, Mollusks, p. 39.

Chiefly or wholly found at high elevations, and very rare in the region north of Cave Creek.

E. fulvus alaskensis differs chiefly from *fulvus* by having about one whorl less in shells of similar size. On the first whorl the radial striæ begin at the first fourth, and are about as close as on the rest of the shell. There are no spiral striæ on the first or later whorls. The last whorl has 90 to 105 striæ in 1 mm. *E. f. alaskensis* was described from Dyea Valley, Alaska. It is also before us from Petropavlovsk, Kamchatka, collected by Dr. William H. Dall. It extends southward in the Rocky Mountains to the Chiricahua and Huachuca ranges, in southern Arizona, chiefly at high elevations.

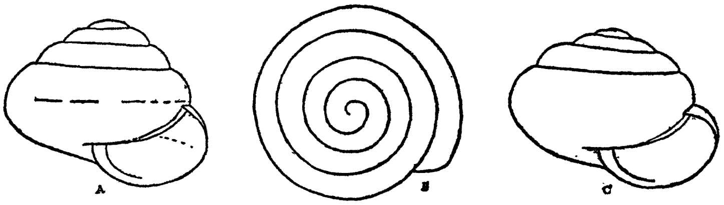


Fig. 26.—*Euconulus fulvus alaskensis* Pils. A, B, cotype, Dyea Valley, Alaska; C, Head of Cave Creek, Chiricahua Mountains.

Mr. E. G. Vanatta has made a careful study of the American forms of *Euconulus fulvus* in order to determine the status of the Chiricahuan form, using high magnification to bring out the minute sculpture. It appears that all the forms examined have a minute sculpture of excessively close, regular vertical striæ, though in some examples it is less distinct than in others. This sculpture, when strongly developed, lends a silk-like luster to the surface in quite fresh examples.

In *E. fulvus* from the northeastern United States the first whorl has fine spiral striæ and very indistinct traces of vertical (radial) striæ, not seen in some but legible, though weak, in other examples. The upper surface of the last whorl has about 126 vertical striæ in 1 mm., crossed by spiral striæ. There are about 6 whorls (figs. 27, B, C, Herkimer Co., N. Y., No. 59,521 A. N. S. P., alt. 2.4, diam. 3.1 mm. Fig. D, Buckfield, Oxford Co., Maine, No. 87,302 A. N. S. P., alt. 3.5, diam. 3.4 mm.). The largest examples seen are from Buckfield, Me., collected by Mr. J. A. Allen.

An English example (fig. 27A, Burnley, England, R. Walton coll., 75,912 A. N. S. P.) has distinct vertical striæ on the first whorl as well as spirals, and on the last whorl there are 140 vertical striæ in 1 mm., with no noticeable spirals. Alt. 2.4, diam. 2.8 mm.

It seems that there is considerable variation in the minute sculpture of *E. fulvus*, though it appears to be always somewhat coarser than in *E. chersinus* and, in the average at least, finer than in *E. fulvus alaskensis*.

Euconulus chersinus (Say) is, of course, a very distinct species from all of the preceding. No conchologist who actually examines *fulvus* and *chersinus* with an ordinary hand lens could lump them. Mr. Vanatta's study of the microscopic sculpture has shown that there is little real difference between *chersinus* and *polygyratus*, and we are now disposed to drop the latter as a synonym. *E. chersinus* (*polygyratus*) occurs associated with *fulvus* in some Maine localities. *E. chersinus* has not been found in New Mexico or Arizona.

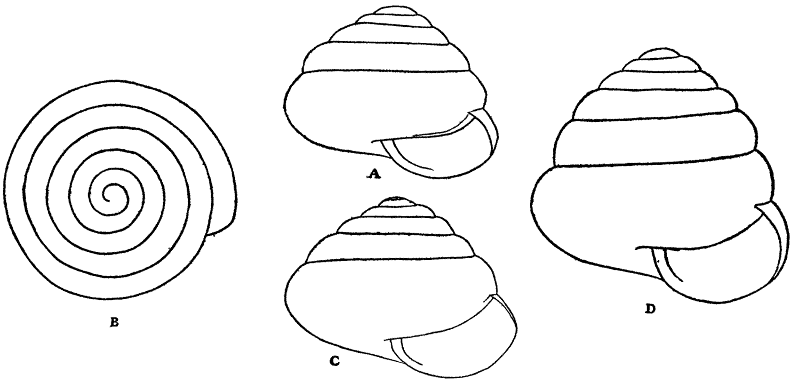


Fig. 27.—*Euconulus fulvus* (Müll.). A, Burnley, England; B, C, Herkimer County, N. Y.; D, Buckfield, Maine.

ENDODONTIDÆ.

Pyramidula (Gonyodiscus) cronkhitei (Newc.).

Foot of talus about half a mile below Reed's place, in Cave Creek Canyon, Station 11; head of cave, 8,000 feet; Barfoot Park; head of Pine Canyon; Long Park, 8,000 feet; "Box" of Rucker Canyon.

Helicodiscus eigenmanni arizonensis Pils. and Ferr.

Quartzite Peak near Fort Bowie; head of west branch of Big Emigrant Canyon and at Station 2; White Tail Canyon at Stations 4, 10, in the Box Canyon, and on both sides below the junction of Indian Creek; Cave Creek Canyon at Stations 4 and 14, 8,000 feet; Rustler's Park; head of Pine Canyon; Shake Gulch, Limestone Mountain.

Radiodiscus millecostatus Pils. and Ferr.

Head of Cave Creek, 8,000 feet, Station 14; Barfoot Park, Station 3;

Pine Canyon, 7,500 feet; Rustler Park; Long Park, 8,000 feet; "Box" in Rucker Canyon.

This species is new to the Chiricahuas. It was originally described from the Huachuca range. It was found in some profusion in Long Park, many specimens exceeding the type in size, the largest 2.3 mm. in diameter.

It is somewhat remarkable that this form, belonging to a southern genus and here at the northern edge of its known range, should be found only at high levels.

Punctum californicum Pils.

P. californicum Pils., Nautilus, XI, April, 1898, p. 134 (Fish Camp, Fresno County, California).

Head of Cave Creek, Station 14, 8,000 feet; Rustler Park; Long Park. Found with *Radiodiscus.*

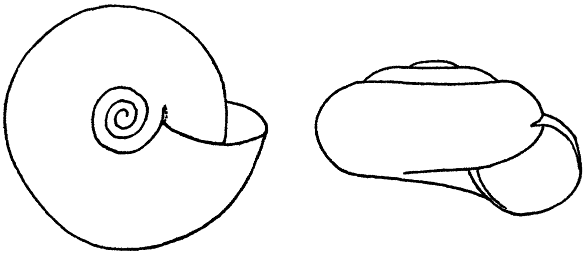


Fig. 28.—*Punctum californicum* Pils., Rustler Park, Chiricahuas.

Only seven examples of this atom of life were found, none of them as large as the California types, and probably not fully mature. The figured example measures alt. .82, diam. 1.35, width of umbilicus .35 mm., whorls 3¼. The first 1¼ whorls are smooth; then very fine obliquely radial striæ appear. On the last whorl the striation is dense and fine, with thin delicate cuticular laminæ on the striæ, which give fresh shells a satin sheen where the light strikes, the color of the shell being light chestnut. Striæ at nearly regular intervals are slightly more prominent. At the periphery there are about 40 of the more prominent striæ in 1 mm. The umbilicus is one-fourth the total diameter.

An adult shell of the type lot of *P. californicum* measures 1.8 mm. diam., umbilicus .42 mm., therefore, slightly less than one-fourth the diameter. The sculpture is similar to that of Chiricahua *P. californicum.*

This snail is new to Arizona, having been known hitherto only from

Fresno County, California. It is one of the very few forms common to Arizona and the West Coast.

VALLONIIDÆ Pilsbry.

Vallonia perspectiva Sterki.

Summit of Cross J Mountain, Big Emigrant Canyon; Paradise Canyon below Paradise; White Tail Canyon; Spring in lower Rucker Canyon; Limestone Mountain.

FERUSSACIDÆ Bourguignat.

Cochlicopa lubrica (Müll.).

Chiricahua Mountains: Ridge between White Tail Canyon and the Pinery, Station 3; Jhu Canyon; Paradise Canyon; Cave Creek Canyon at Stations 4, 5 and 11 and 14 F, very scarce; Barfoot Park; head of Pine, 7,500 feet; Long Park, 8,000 feet; Box of Rucker Canyon.

PUPILLIDÆ Turton.

Pupilladæ Turton, Manual of the Land and Fresh-water Shells of the British Islands, p. 97 (1831).
Pupillidæ, Pilsbry, Nautilus, XVIII, p. 107 (Jan., 1905).
Pupidæ of authors.

The northern (Canadian) forms of this group approach their southern limit in the ranges of Southern Arizona. *Vertigo* is represented only by a few puny forms at high elevations. The Upper Sonoran Bifidariæ predominate, especially those of the section *Immersidens*.

The family name *Pupillidæ* replaces *Pupidæ* because the generic term *Pupa* was not based upon a member of this family.

Genus **PUPILLA** 'Leach' Turton.

Pupilla hebes (Ancey).

Box in Rucker Canyon; Spring branch of Rucker. The sinistral form of *P. hebes* (which we will call form *nefas*) was taken in Pine Canyon, 7,500 feet (type loc.), and at the head of Cave Creek, Station 14, at 8,000 feet. No dextral examples were taken at either of these stations.

Genus **BIFIDARIA** Sterki.

Bifidaria pellucida hordeacella (Pils.).

Summit of Cross J Mountain, Big Emigrant Canyon; Paradise Canyon below Paradise; White Tail Canyon; Cave Creek Canyon on slope below the cave; Shake Gulch, Limestone Mountain.

Bifidaria quadridentata Sterki.

Barfoot Park, one specimen.

Section ALBINULA 'Ckll' Sterki.

Bifidaria pilsbryana Sterki.

Rustler's Park; White Tail Canyon; Pine Canyon, 7,500 feet; Box in Rucker Canyon; Limestone Mountain, in Shake Gulch.

Section IMMERSIDENS Pils. and Van.

In the central sierras, from the Grand Canyon of the Colorado to the Mexican State of Michoacan, a distance of over 1200 miles, the typical (or *procèra*) group of Bifidaria gives place to a great extent to a group in which the angular and parietal lamellæ are less united, joined only at the inner end of the angular lamella. The basal fold, when present, is radial, or transverse to the cavity. This group is morphologically in a more primitive stage than the eastern Bifidariæ, in which the angular and parietal lamellæ are more completely concrescent. Some of the species, however, have evolved very complicated apertures. Such forms as *B. perversa* and *B. ashmuni* are to be viewed as highly evolved members of a low group. *Immersidens* stands intermediate between *Bifideria s. str.* and *Sterkia.* In the latter group the angular and parietal lamellæ are not united.

The following forms from Arizona and New Mexico belong here:

Bifidaria perversa Sterki.
" *ashmuni* Sterki.
" *ashmuni minor* Sterki.
" *cochisensis* Pils. and Ferr.
" *cochisensis oligobasodon* Pils. and Ferr.
" *dalliana* Sterki.
" *bilamellata* Sterki and Clapp.

Bifidaria prototypus Pils., from Michoacan, Mexico, also belongs to the group, as a terminal member of a form-chain composed of *ashmuni*, *cochisensis, oligobasodon, prototypus,* which constitute successively simpler links in the chain. Probably the great unknown mountain region of Northern Mexico will supply other members of the group.

In order to complete the account of *B. ashmuni* and its allies, forms from the Huachuca Mountains and elsewhere have been described and illustrated below.

Key to Species of Immersidens.

a.—Shell sinistral, last whorl straightened and produced forward (fig. 29)..*B. perversa* Sterki.
a^1.—Shell dextral.

b.—Columellar lamella running forward on the parietal wall in the position of an infraparietal lamella; inner end of the parietal lamella curving strongly toward the outer wall.
  c.—Length about 2 mm.......... *B. ashmuni* Sterki.
  c^1.—Length 1.6 to 1.8 mm.......... *B. a. minor* Sterki.
b^1.—Columellar lamella normal in position, horizontal and conspicuous in a front view.
  c.—Parietal barrier λ-shaped, the inner end curving more or less towards the outer wall.
    d.—Basal fold well-developed, radial. *B. cochisensis* P. and F.
    d^1.—Basal fold minute; angular lamella reduced. *B. c. oligobasodon* P. and F.
    d^2.—Basal fold wanting; angular lamella reduced. *B. prototypus* Pils.
  c^1.—Parietal lamella straight or bending slightly toward the columella at its inner end; shell small, rather slender.
    d.—Length 2, diam. 0.85 mm., or smaller; nearly cylindric. *B. dalliana* Sterki.
    d^1.—Length 2 to 2.4, diam. 0.9; spire tapering more. *B. bilamellata* S. and C.[29]

Bifidaria perversa Sterki. Fig. 29.

Bifidaria perversa Sterki, Nautilus, XII, December, 1898, p. 90 (Nogales).

Found in the Chiricahuas in the Valley of Turkey Creek below Paradise and in White Tail Canyon. Heretofore known only from Nogales and the drift débris of the San Pedro River at Benson, Arizona.

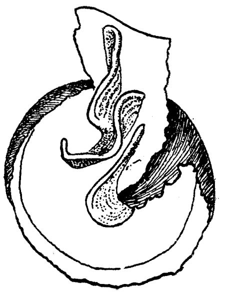


Fig. 29.—*B. perversa*, basal view, most of the basal wall removed to show the angular, parietal and and columellar lamellæ.

Bifidaria ashmuni Sterki. Fig. 30, *a*, *b*, *c*.

Bifidaria ashmuni Sterki, Nautilus, XII, Sept., 1898, p. 49 (Santa Rita Mountains, Arizona; Cook's Peak and Dripping Springs, Organ Mountains, New Mexico).

Bifidaria ashmuni form *minor* Sterki, t.c., Dec., 1898, p. 92 (Nogales, Arizona).

The typical form of *B. ashmuni* is nearly cylindric, tapering but slightly, composed of five strongly convex whorls. The last whorl becomes straightened and slightly sinuous in basal view, and has a more or less conspicuous oblique swelling or crest some distance behind the aperture. This crest is not always so strong, as shown in fig. 30 *c* (a specimen from Page's Ranch, Oak Creek, in central Arizona). The peristome is well expanded, continuous, and usually stands shortly free from the whorl in front. The parietal lamella is sigmoid, bending far to the right at its inner end. The angular lamella, also sigmoid, runs from the peristome to the parietal lamella, the two lamellæ together forming a figure like the letter λ. The columellar lamella is broad and horizontal far within, but near the aperture *it runs out upon the parietal wall,* where it appears as a more or less elevated cord between the parietal lamella and the columella, occupying, therefore, the place of an infraparietal lamella. These lamellæ are well shown in fig. 30 *b*, a basal view in which the base of the shell has been removed. The upper palatal fold is short, situated some distance within the mouth, but visible from in front. The lower palatal is long, entering, and so deeply immersed that it is not visible in a front view, being concealed behind the massive parietal barrier. There is a radially placed basal fold, scarcely or not visible in a front view. Length about 2, diam. 1 mm.

---

[29] *Bifidaria bilamellata* Sterki and Clapp, *Nautilus*, XXII, pl. 8, fig. 7 (March, 1909). Sterki, *Nautilus*, XXII, p. 126 (April, 1909). Yuma County, Arizona.

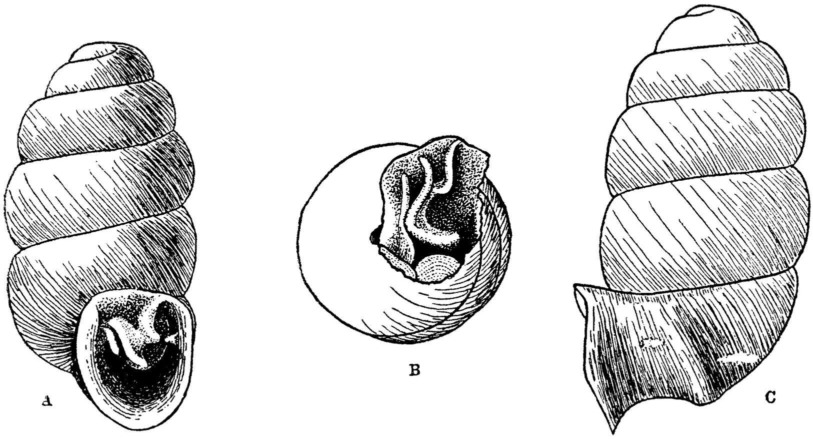


Fig. 30.—*Bifidaria ashmuni* Sterki. A, B, Florida Mountains, New Mexico; C, Page's Ranch, Oak Creek, Central Arizona.

Arizona: Coconino Co., Grand Canyon, on the Bright Angel trail about 100 feet below the rim (Ferriss and Pilsbry); Yavapai Co., Verde River, Walnut Gulch, Mescal Gulch and Kirwagen's ranch, all near Jerome, and along Oak Creek at Owensby's and Page's ranch; along the Santa Fe R. R. at Holbrook, Navajo Co., and Navajo Springs, Apache Co. (Ashmun); Cochise Co., in the Chiricahua range in White Tail Canyon below the mouth of Indian Creek and on Limestone Mountain (Ferriss and Pilsbry); Ash Canon, Huachuca range (Ferriss and Daniels); Nogales, S. Cruz Co. (Ashmun). New Mexico: Valencia Co., along the Santa Fe R. R., at Grants (Ferriss and Pilsbry) and San Rafael (Ashmun); Mountain Station, Oscura Mountains, Socorro Co., and White Oaks, Lincoln Co., in Central New Mexico (Ashmun); Cook's Peak (U. S. N. M.); Dripping Spring, Organ Mountains (Cockerell); Florida Mountains, Luna Co. (Ferriss and Pilsbry).

B. ashmuni is distinguished by the strong development of the angulo-parietal lamella, which bends far to the right at its inner end, the very deep immersion of the lower palatal and basal folds, the *continuation of the columellar lamella upon the parietal wall, alongside the parietal lamella,* and the longer, usually more gibbous, "neck" of the last whorl.

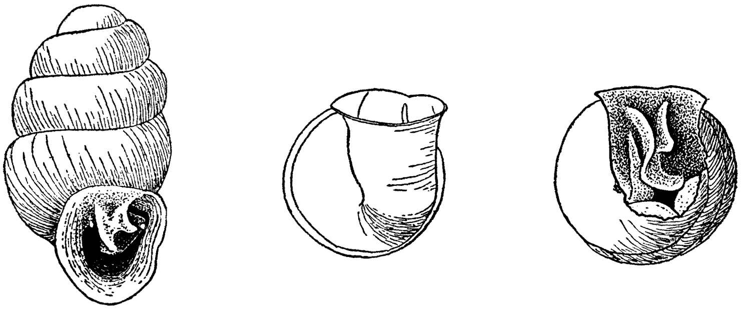


Fig. 31.—*Bifidaria ashmuni minor* Sterki, Nogales, Arizona.

B. ashmuni minor Sterki (fig. 31) is a small race, length about 1.6 mm., with 4 to 4½ whorls, found at Nogales, Arizona, and also on the Mexican side of the international boundary. The aperture is substantially like that of *ashmuni.*

Bifidaria cochisensis n. sp. Figs. 32, 33.

The shell is slightly tapering cylindric, like *B. ashmuni,* but the last whorl is less protracted and the crest or wave behind the aperture is very low, often not noticeable. The peristome is continuous as a slightly raised thread across the parietal wall (or in a less developed form it is rather widely interrupted above). Lamellæ *weaker* than in typical *B. ashmuni,* especially the angular lamella, which is straighter; *parietal lamella less curved at its inner end.* Columellar lamella wide and horizontal, *not continued upon the parietal wall.* Basal and lower palatal folds less deeply immersed than in *B. ashmuni,* readily visible in the mouth, the basal fold small.

Length 2.5, diam. 1.1 mm. }
" 2.2, " 1.1 " } Cotypes, Tanner Canyon, fig. 32.
" 2.15, " 1.1 " Santa Rita Mountains, fig. 33.

Southeastern Arizona: Chiricahua Mountains, White Tail Canyon; Summit of Cross J Mountain, Big Emigrant Canyon (Ferriss and Pilsbry). Huachuca Mountains, Tanner Canyon, 6,000 feet (Ferriss, type loc.). Santa Rita Mountains (Ashmun).

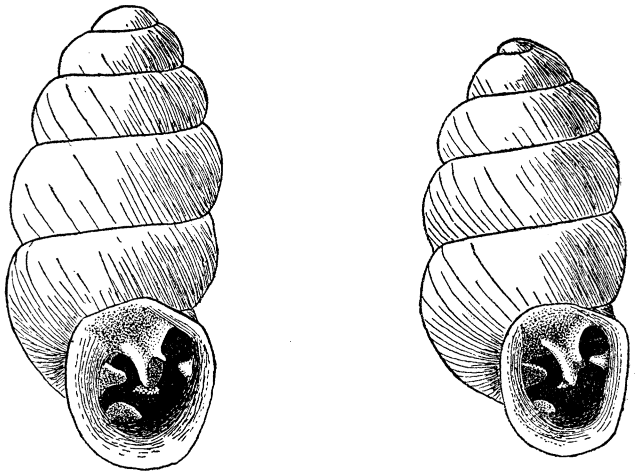


Fig. 32.—*Bifidaria cochisensis* P. and F. Types from Tanner Canyon, Huachuca Mountains.

The absence of a forward continuation of the columellar lamella on the parietal wall, between the parietal lamella and the columellar wall, is the most prominent feature of this species, though it has several other constant, if less conspicuous, differential characters. It is decidedly less aberrant than *B. ashmuni*, the lamellæ and folds, as well as the less protracted last whorl, approaching the normal *Bifidaria* type.

A modification of *B. cochisensis* also occurs in the Huachucas at Tanner Canyon and in the Chiricahua range on Limestone Mountain. The shell is smaller than usual in *cochisensis*, about 1.9 or 2 mm. long. The teeth are much weaker, especially the angular lamella. The inner end of the parietal lamella is not much curved and is readily visible in an obliquely basal view in the aperture. The basal and palatal folds are less deeply placed, the lower palatal being visible *below* the apex of the parietal barrier in a front view. The basal fold is very small. The upper margin of the peristome is adnate for some distance. In this form, or race, if such it proves to be, *B. ashmuni cochisensis* makes its nearest approach to *B. dalliana* and to the following race.

Possibly Dr. Sterki at the time of his original description had *cochisensis* before him, together with typical *ashmuni*, since he mentions specimens from the Santa Rita Mountains. We have examined a lot collected by Mr. Ashmun at that place and find them all to be *cochisensis*. The terms of Sterki's original description apply only to the form herein defined as *ashmuni*, for he mentions the crest "forming a projecting angle at the base" and the columellar lamella "ascending to the body-whorl between the parietal and columella." Careful examination of a series of several thousand examples, supplying data for the present account, has shown no intergrading forms between *ashmuni* and *cochisensis*, yet careful cleaning of the aperture is necessary for their discrimination.

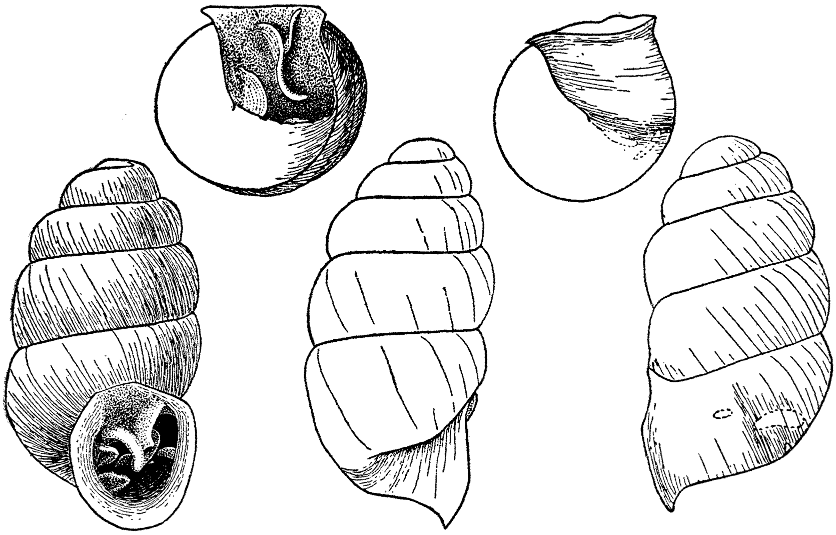


Fig. 33.—*Bifidaria cochisensis* P. and F. Santa Rita Mountains, Arizona.

Bifidaria cochisensis oligobasodon n. subsp. Fig. 34, *a*, *b*, *c*.

The shell is externally similar to *B. cochisensis*, but differs by the reduction of all the teeth. The parietal barrier is simplified (fig. 34 *b*), and the basal fold is reduced to a minute tubercle or a mere vestige, or in a few apparently mature shells it seems to be wholly lost. Parietal margin adnate.

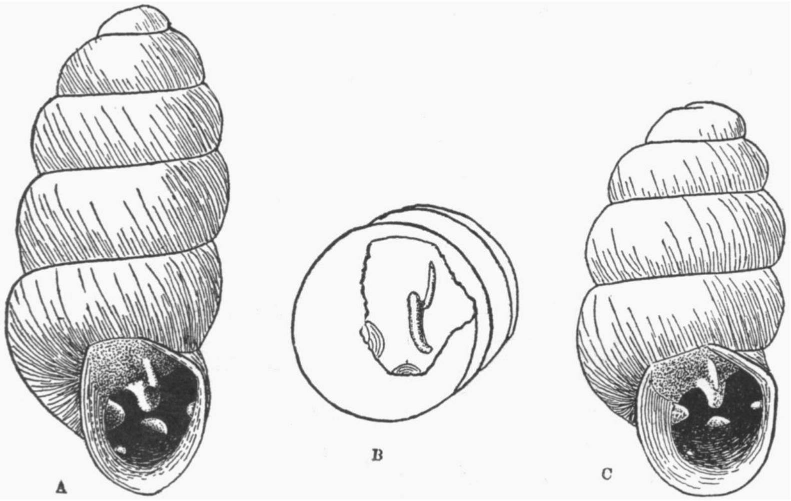


Fig. 34.—*Bifidaria cochisensis oligobasodon* P. and F. Ash Canyon, Huachuca Mountains.

Length 2.6, diam. 1.1 mm.
" 2.1, " 1 "

Ash Canyon, Huachuca range. Types No. 97,444 A. N. S. P., cotypes in Ferriss coll.

This form would be considered specifically distinct from *cochisensis* were it not approached by a small form of that species from Tanner Canyon, which has weaker teeth than the larger typical *cochisensis*. *B. c. oligobasodon* stands very near *B. prototypus* Pils.[30] (fig. 35),

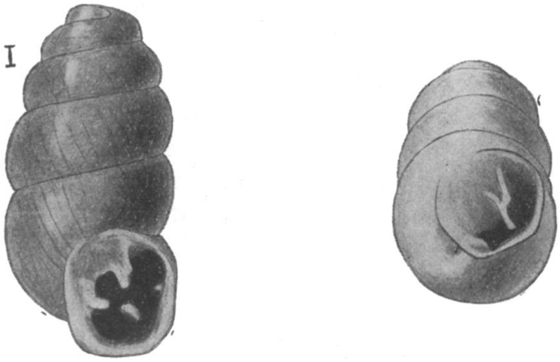


Fig. 35.—*Bifidaria prototypus* Pils.

---

[30] *Proc. A. N. S. Phila.*, 1899, p. 400.

described from the State of Michoacan, Mexico, figured here for comparison. In a long series of *prototypus* no specimen with even a vestigeal basal tooth was found. In view, therefore, of the very wide separation of the two forms geographically, it may be best to treat them as specifically diverse.

Bifidaria dalliana Sterki. Fig. 36.

Bifidaria dalliana Sterki, Nautilus, XII, p. 91, Dec., 1898. Pilsbry and Vanatta, Proc. A. N. S. Phila., 1900, p. 593, pl. 22, fig. 8.

Chiricahua Mountains: Quartzite Peak near Fort Bowie; White Tail Canyon in several places (Ferriss and Pilsbry); Limestone Mountain and Shake Gulch (Ferriss).

Other Arizona localities in collection A. N. S. P. are Nogales (type loc.), Santa Rita Mountains, Montezuma's Well, Salt River near Tempe, Kirwagen's ranch near Jerome; all collected by Mr. Ashmun.

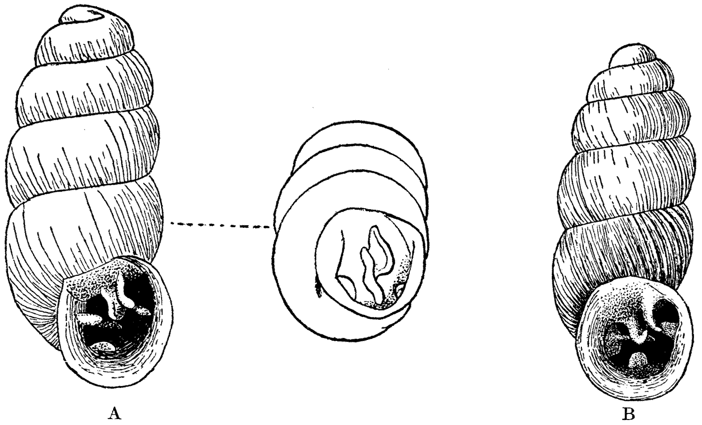


Fig. 36.—A. *Bifidaria dalliana* Sterki, front and obliquely basal views of a specimen from White Tail Canyon below the junction of Indian Creek, Chiricahua Mountains. B, *B. bilamellata* S. and C, type.

B. dalliana is related to *B. cochisensis*, but differs by being conspicuously more slender, resembling *B. p. hordeacella* in shape, but it diverges more fundamentally by the parietal lamella, the inner end of which turns slightly *toward the columella*, while in *B. ashmuni*, *cochisensis* and *perversa* the inner end bends towards the outer wall.

In the Chiricahuas the specimens are often longer than the types, one figured here measuring 2 mm. long, .85 wide.

Bifidaria bilamellata Sterki and Clapp stands very close to *B. dalliana*, but it differs by having a perceptibly more tapering spire, which is somewhat longer, and the columellar lamella has a vertical callus at its inner end (weaker or wanting in *dalliana*). The parietal lamellæ are substantially alike in the two species. For comparison we reproduce here the type figure of *B. bilamellata* (fig. 36 B).

Subgenus **CHÆNAXIS** Pils. and Ferr.

Bifidaria tuba Pilsbry and Ferriss.

A few examples were taken by Mort Wien about half a mile from Dos Cabezas Cave, where it occurred with *Holospira*. This extends the known range of the species eastward.

Genus **VERTIGO** Müller.

Vertigo is a distinctly boreal element, confined in the Chiricahuas, so far as our observations show, to high levels. The species are identical with alpine forms of Colorado and Utah.

Vertigo columbiana utahensis Sterki.

Head of Cave Creek, 8,000 feet, one example.

Vertigo milium Gld.

Head of Pine Canyon, one specimen.

Vertigo modesta parietalis Anc.

Head of Cave Creek, 8,000 feet; Long Park.

Vertigo coloradoensis basidens Pils. and Van.

Rustler's Park.

SUCCINEIDÆ.

Succinea avara Say.

Chiricahua Mountains: Cave Creek Canyon on the slope below the cave and at Station 6.

BASOMMATOPHORA.

No fresh-water snails were taken in the streams of the Chiricahuas, but Pilsbry found two species in the *ciénega* about midway between the Chiricahua and the Peloncillo or Stein's Peak ranges: *Lymnæa cockerelli* Pils. and Ferr. and *Physa virgata* Gld. Both are widely if sparsely distributed in Arizona and New Mexico.

It is said that sometimes blind fish are washed out of the swollen springs in the ciénega when the snow melts on the mountains.

PELECYPODA.

Pisidium abditum huachucanum Pils.

Spring branch, head of Rucker Canyon, many young specimens only; Box in Rucker Canyon.

Explanation of Plates I–XIV.

Figures 35 and 36 B were drawn by Helen Winchester; the other figures were drawn or photographed by H. A. Pilsbry.

Plate I—Figs. 1, 2, 3—*Sonorella bicipitis* n. sp. Types from Station 1, Buckeye Canyon, No. 94,328 A. N. S. P.

Figs. 4, 5—*S. bicipitis.* Nine-mile Water Hole. Nos. 94,324 and 89,908 A. N. S. P.

Figs. 6, 7, 8, 9—*Sonorella optata* n. sp. Types from head of Big Emigrant Canyon. No. 94,319 A. N. S. P.

Fig. 10—*S. optata*—Cleft in summit between forks of Big Emigrant Canyon. No. 94,321 A. N. S. P.

Figs. 11, 12, 18, 19—*S. optata.* West side of Big Emigrant Mountain. No. 94,320 A. N. S. P.

Figs. 13, 14, 15, 16—*Sonorella bowiensis* Pils. Topotypes, from Quartzite Peak, near Fort Bowie. No. 94,327 A. N. S. P.

Fig. 17—*S. optata*, small form. Head of Big Emigrant Canyon. No. 99,789 A. N. S. P.

Plate II—Figs. 1, 2, 3—*Sonorella virilis* Pils. Cave Creek, Station 11 (topotypes of var. *circumstriata*). No. 94,332 A. N. S. P.

Figs. 4, 5—*S. virilis.* Two miles up the south fork of Cave Creek. No. 94,335 A. N. S. P.

Fig. 6—*S. virilis.* Spring Branch near Rucker Camp, head of Rucker Canyon. No. 97,563 A. N. S. P.

Figs. 7, 8, 9—*Sonorella virilis leucura* n. subsp. White Tail Canyon, Station 14. No. 99,682 A. N. S. P.

Figs. 10, 11—*Sonorella micra* n. sp. Station 10, White Tail Canyon. No. 94,334 A. N. S. P.

Fig. 12—*S. micra.* Station 17, White Tail Canyon. No. 94,330 A. N. S. P.

Figs. 13–18—*Sonorella binneyi* n. sp. Horseshoe Canyon.

Plate III—Fig. 1—*Sonorella bicipitis* Pils and Ferr. Genitalia of specimen from Buckeye Canyon. Station 3. × 3. No. 94,326.

Fig. 2—*S. bicipitis.* Genitalia of specimen from Nine-mile Water Hole. No. 94,324. × 3.

Fig. 3—Side of the head of same specimen.

Fig. 4—*S. bicipitis.* Penis opened to show the papilla. Buckeye Canyon, Station 4. No. 94,325.

Fig. 5—*Sonorella binneyi* Pils and Ferr. Genitalia of No. 97,414. Horseshoe Canyon.

Fig. 6—*S. bicipitis.* Sole of specimen from Nine-mile Water Hole. No. 94,324.

Fig. 7—*S. bicipitis.* Genitalia of specimen from Buckeye Canyon, Station 1. × 3. No. 94,328 (type lot).

Plate IV—Fig. 1—*Sonorella optata* Pils and Ferr. Genitalia of No. 94,322. Big Emigrant Mountain, × 3, with details of penis, papilla and the vestigeal flagellum (*fl.*).

Fig. 2—*S. optata.* West Side of Big Emigrant Canyon. No. 94,320. × 4.

Fig. 3—*S. optata.* Big Emigrant Canyon, Station 1. No. 94,319. × 4.

Fig. 4—*S. optata.* Cleft in Big Emigrant Canyon. No. 94,321. × 4.

Fig. 5—*S. optata.* Genitilia of young snail. No. 94,323. × 14. Outline of penis papilla shown by broken line.

Fig. 6—*Sonorella bowiensis* Pils. Genitalia of a topotype. × 3. No. 94,327.

Fig. 7—*S. optata.* Genitalia of a nearly mature snail. No. 94,323. × 4. Cross J. Mountain.

Plate V—Fig. 1—*Sonorella micra* Pils and Ferr. Genitalia. × 4. No. 94,334. From Station 10, White Tail Canyon. The penis is extended, its papilla projecting.

Fig. 2—*S. micra.* Detail of same specimen showing the epiphallus extended.

Fig. 3—*S. micra.* No 94,330. × 4. Penis normally retracted, with detail of end of the papilla.

Fig. 4—*S. virilis* Pils. Specimen from Station 11, Cave Creek Canyon. × 2. No. 94,332.

Fig. 5—*Sonorella virilis leucura* Pils. and Ferr. × 2. White Tail Canyon, Station 4. No. 94,331. The twisted condition of the penis is an accidental or individual peculiarity of this specimen.

Fig. 6—*S. virilis.* × 2. Cave Creek, Station 13. No. 94,335. With detail of opposite side of the vagina

Plate VI—Figs. 1, 2, 3—*Oreohelix barbata* Pils. An adult and two immature individuals from the head of Turkey Creek.

Fig. 4—*O. barbata.* Less fully scaled form with blunt periphery. Head of Rucker Canyon, Station 10A.

Figs. 5, 6, 7—*O. barbata minima* Pils. and Ferr. Rucker Canyon, Station 11½A.

Plate VII—Figs. 1, 2, 3, 4—*Ashmunella lepiderma* n. sp. White Tail Canyon, Station 11.

Figs. 5, 6, 7—*A. lepiderma.* Station 17.

Plate VIII—Figs. 1-8—*Ashmunella duplicidens* Pils.

Plate IX—Figs. 1, 2—*Ashmunella esuritor* Pils. Near Barfoot Park, Station 2. No. 92,205. Elevated specimen.

Figs. 3—Pine Canyon, No. 97,930. Elevated specimen.

Figs. 4, 5—Near Barfoot Park. No. 92,205. Depressed specimen.

Figs. 6, 7, 8—East side of Barfoot Park. No. 94,432. Diameter 16⅓ mm.

Fig. 9—*Ashmunella metamorphosa* Pils. Aperture of type specimen. No. 88,885.

Plate X—Fig. 1—*Ashmunella chiricahuana* (Dall). Falls of Cave Creek. No. 97,427 A. N. S. P.

Fig. 2—*Ashmunella esuritor* Pils. E. side Barfoot Park. No. 94,432.

Fig. 3—*Ashmunella esuritor.* Topotype. No. 92,205.

Fig. 4—*Ashmunella chiricahuana* (Dall). Head of Cave Creek, near Long Park. No. 94,430.

Fig. 5—*Ashmunella esuritor* Pils. E. side Barfoot Park. No. 94,432.

Fig. 6—*Ashmunella angulata* Pils. Cave Creek Canyon. No. 87,020.

Fig. 7—*Ashmunella ferrissi* Pils. Topotype. No. 97,925.

Fig. 8—*Ashmunella duplicidens* Pils. Head of Morse Canyon.

Fig. 9—*Ashmunella proxima emigrans* Pils. Cotype. No. 99,604.

Plate XI—Figs. 1, 2, 3, 4—*Holospira arizonensis* Stearns. Topotypes from Dos Cabezas Cave. No. 99,700 A. N. S. P.

Figs. 5, 6, 7, 8—*H. arizonensis emigrans* n. subsp. Head of West branch of Big Emigrant Canyon. No. 99,701 A. N. S. P.

Figs. 9, 10, 11, 12—*H. arizonensis.* Form from Station 2, Big Emigrant Canyon. No. 99,702 A. N. S. P.

Plate XII—Figs. 1, 2—*Holospira cionella* Pils. Two cotypes. No. 87,117. A. N. S. P.

Fig. 3—*H. cionella.* Form from Goodwin Canyon. No. 99,710 A. N. S. P.

Figs. 4-8—*H. cionella.* Forms from Bull Hill, near Fort Bowie. No. 99,709 A. N. S. P.

Figs. 9, 10, 11, 12—*H. cionella.* Forms from Limestone Mountain. No. 97,424, A. N. S. P.

Figs. 13, 14, 15, 16—*H. cionella.* Forms from below Paradise. No. 99,726 A. N. S. P.

Plate XIII—Figs. 1, 2—*Holospira cionella intermedia* P. and F. White Tail Canyon, Station 4. No. 99,717.

Figs. 3, 4, 5—*Holospira cionella intermedia* P. and F. Types. Box Canyon of White Tail. No. 99,684.

Figs. 6, 7. 8—*Holospira cionella intermedia* P. and F. Types. Box Canyon of White Tail, another colony.

Figss. 9, 10, 11, 12—*Holospira cionella intermedia* P. and F. Two forms from head of Onion Creek. No. 99,724.

Figs. 13, 14—Do. Below Station 5, White Tail Canyon. No. 99,718.

Figs. 15, 16—*H. c. capillacea* P. and F. Southeast side of White Tail, below cliffs half way to summit. No. 99,727.

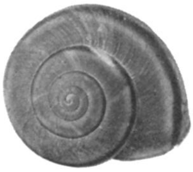
PLATE XIV—Figs. 1, 2, 3, 4—*Holospira chiricahuana ternaria* n. subsp. Cave Creek, Station 6. No. 99,699 A. N. S. P.

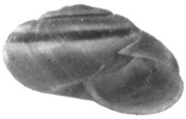
Figs. 5, 6, 7, 8—*Holospira chiricahuana* Pils. Topotypes, cave in Cave Creek. No. 99,696 A. N. S. P.

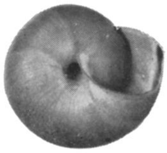
Figs. 9, 10, 11, 12—*H. chiricahuana gracilis* n. subsp. Cave Creek, Station 10. No. 99,698 A. N. S. P.

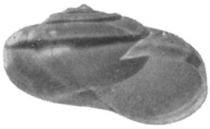
Figs. 13, 14, 15—*H. chiricahuana optima* n. subsp. Cave Creek Station 5. No. 99,697 A. N. S. P.

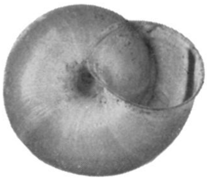
PLATE I.

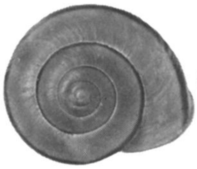

1

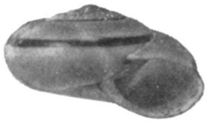

2

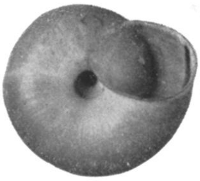

3

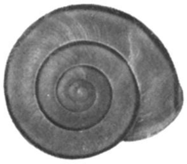

4

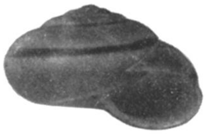

5

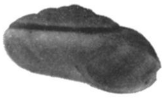

6

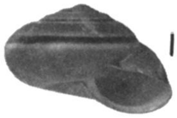

7

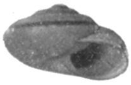

8

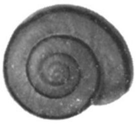

9

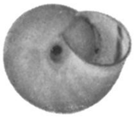

10

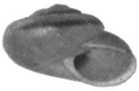

11

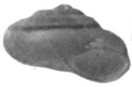

12

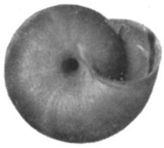

13

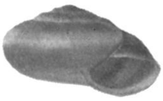

14


15

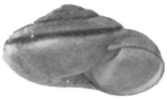

16

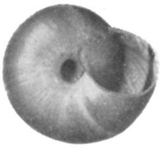

17

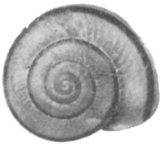

18

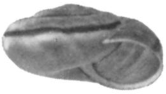

19

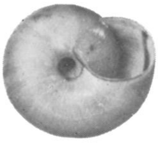
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.

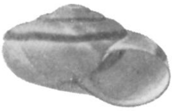

1

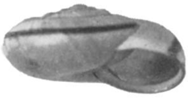

2

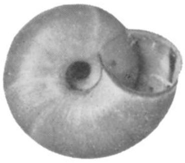

3

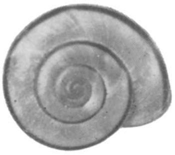

4

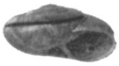

5

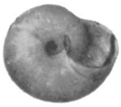

6

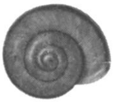

7

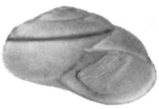

8

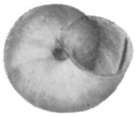

9

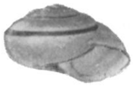

10

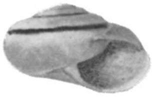

11

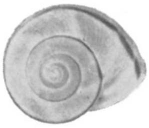

12

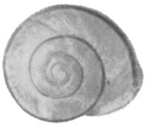

13


14

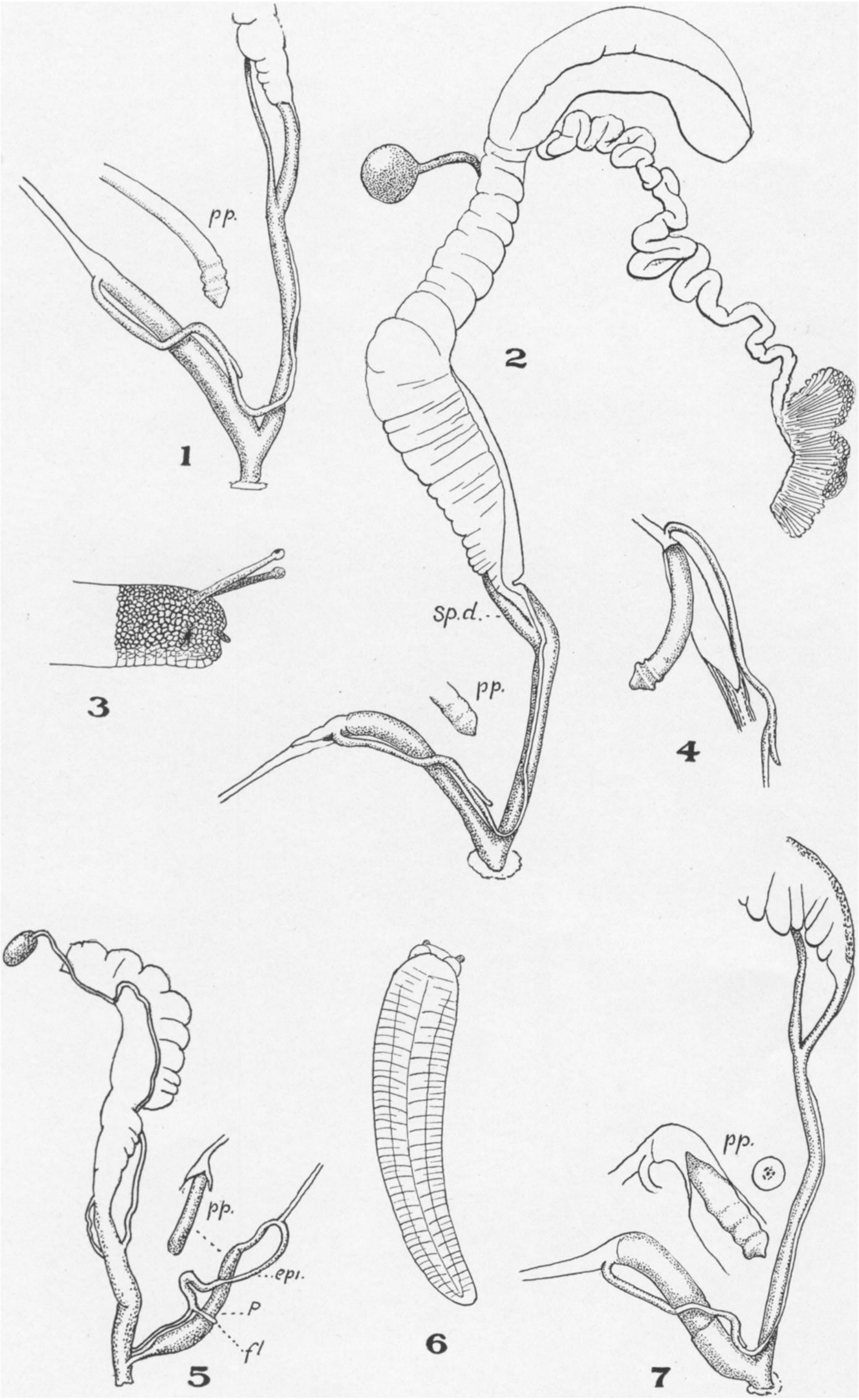

15


16

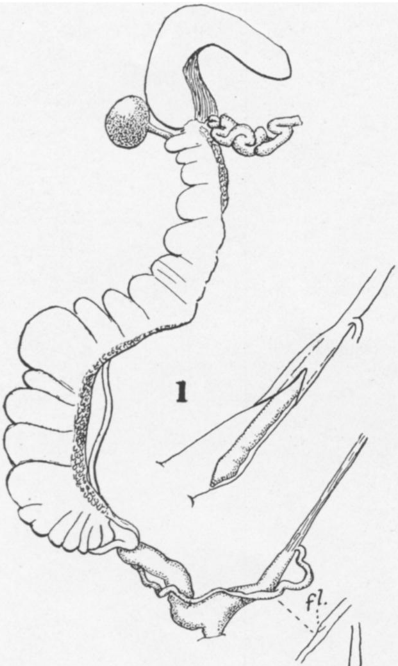

17


18

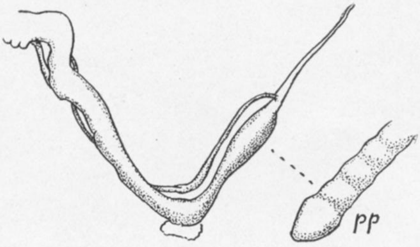
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.



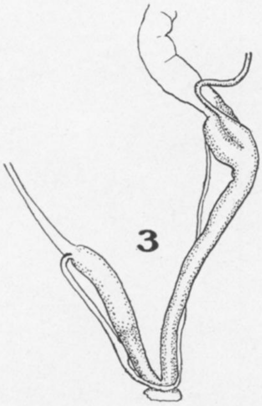
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.



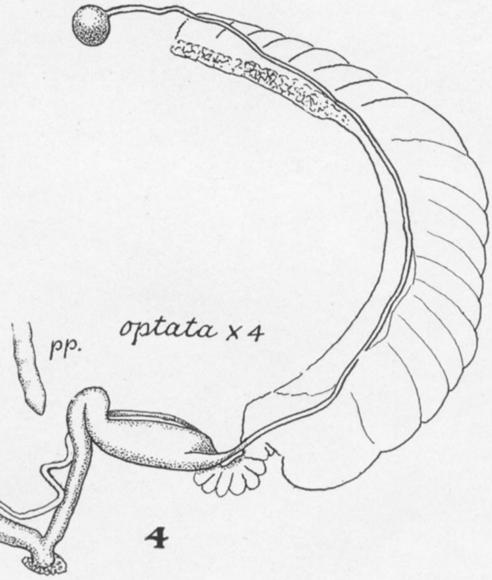
1



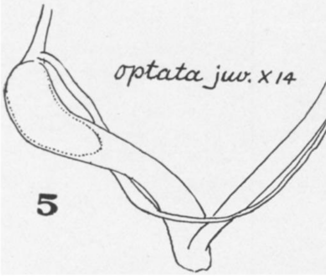
2



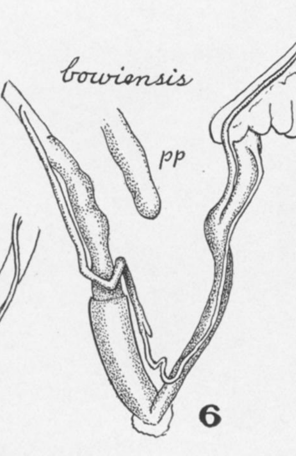
3



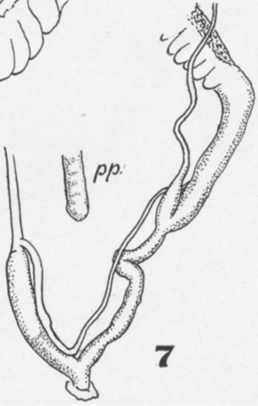
4



5

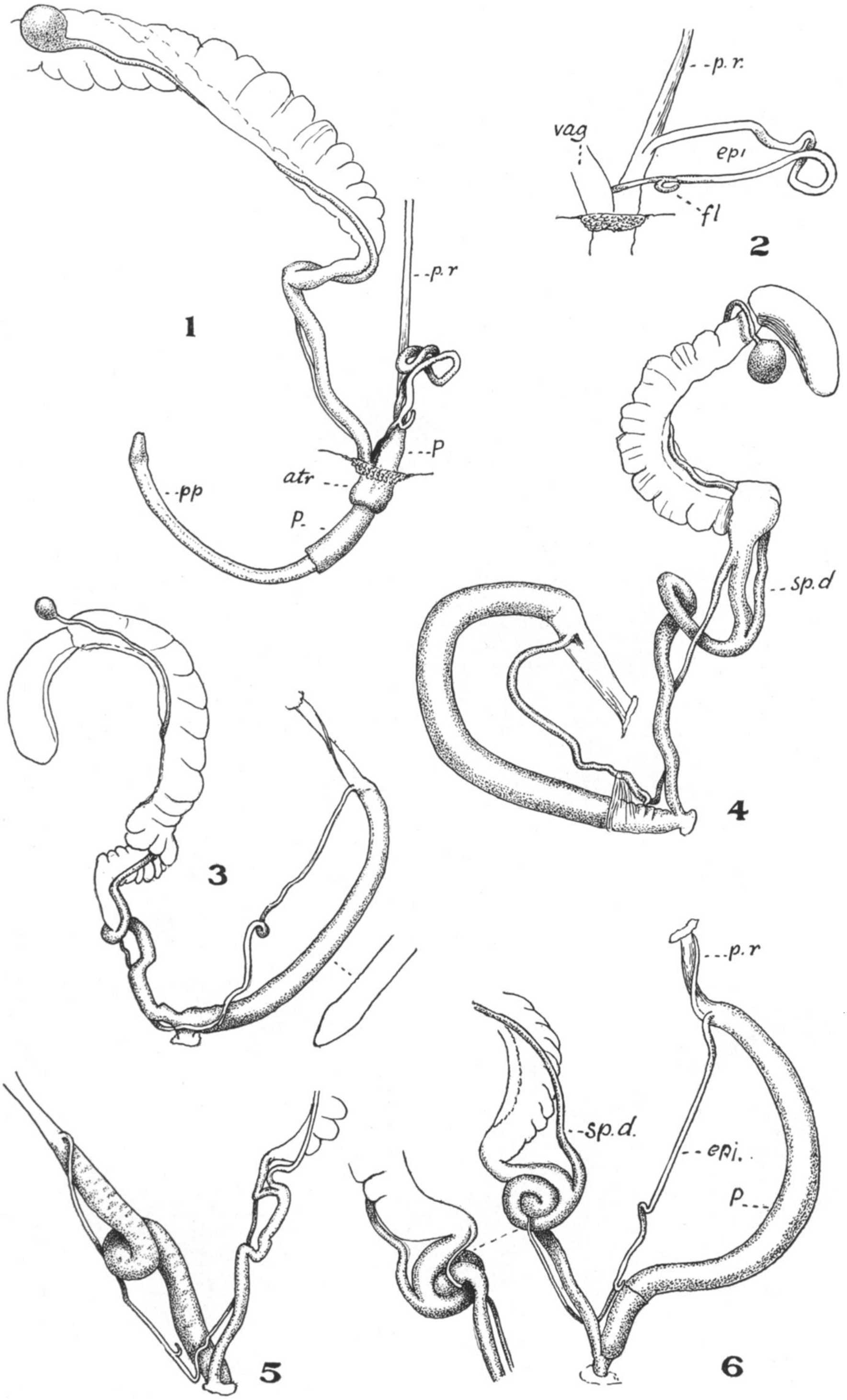


6

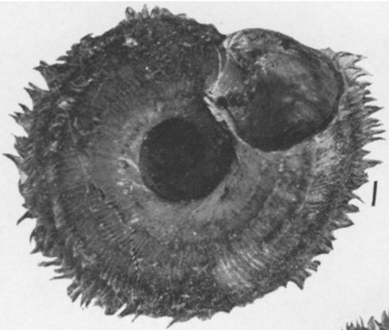


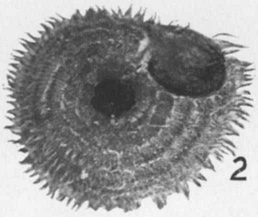
7

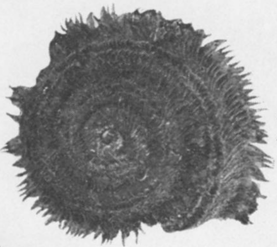
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.

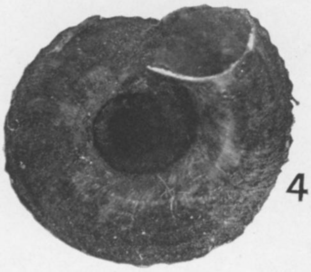


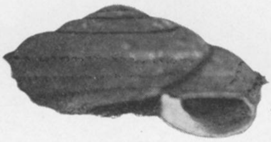
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.

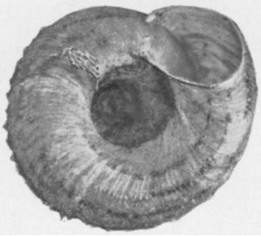

1

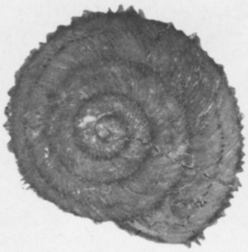

2


3

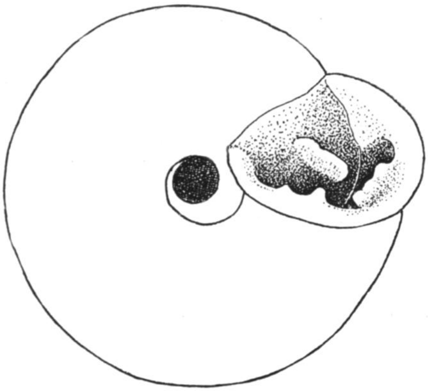

4


5

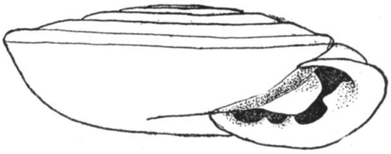

6


7

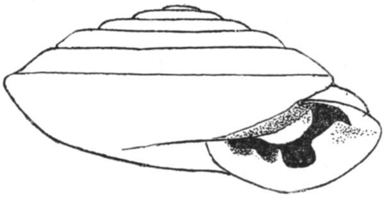
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.



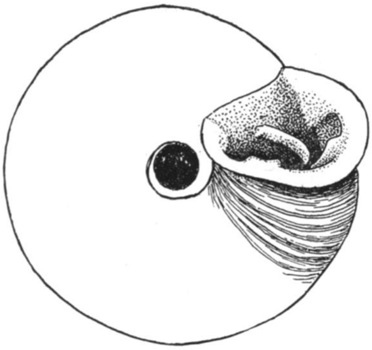
1



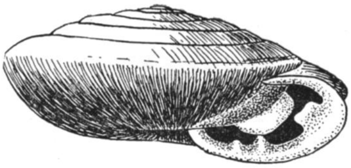
2



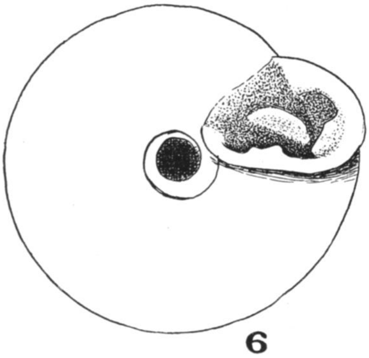
3



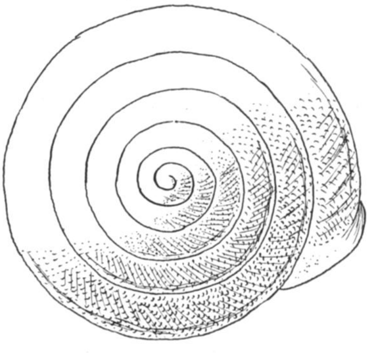
4



5

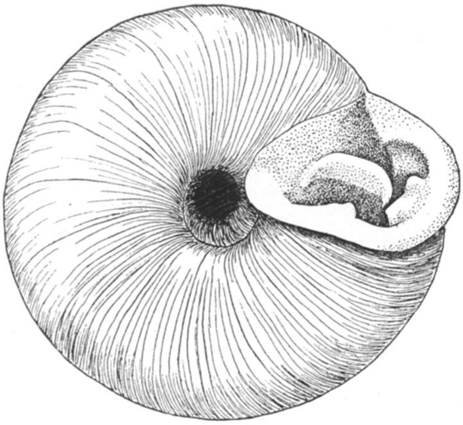


6

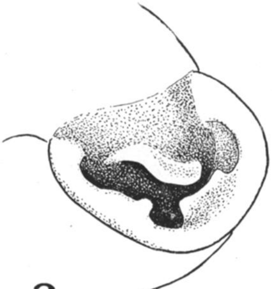


7

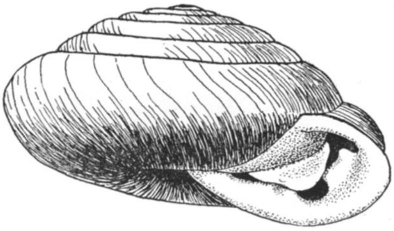
PILSBRY AND FERRISS· MOLLUSCA OF SOUTHWESTERN STATES.



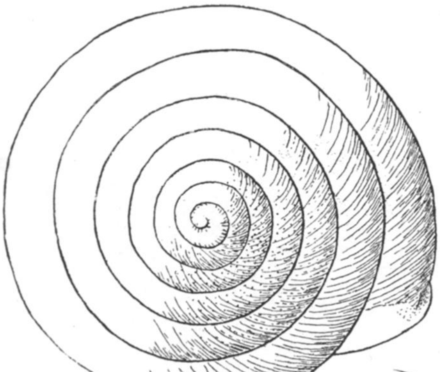
1



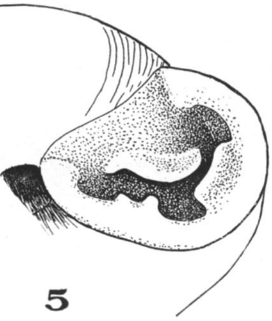
2



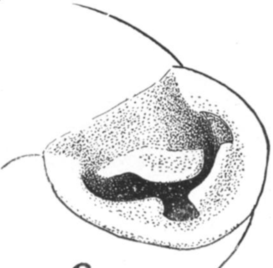
3



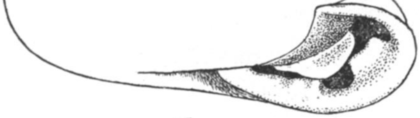
4



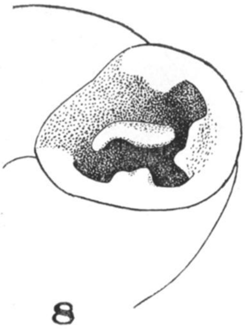
5



6

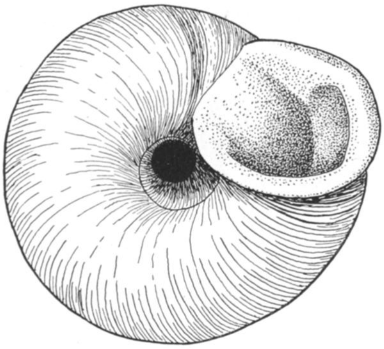


7

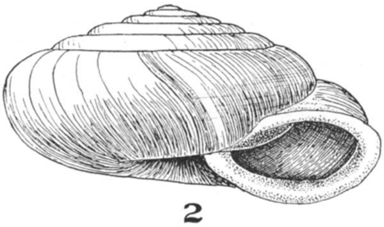


8

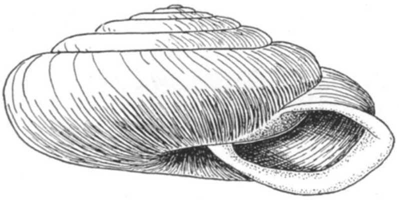
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.



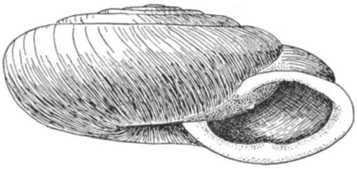
1



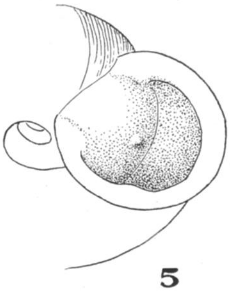
2



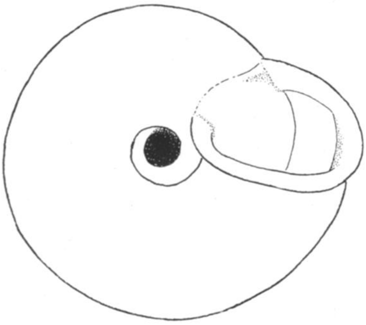
3



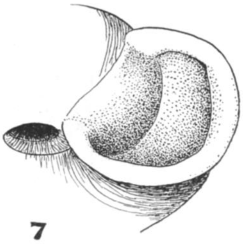
4



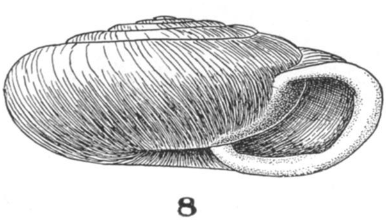
5



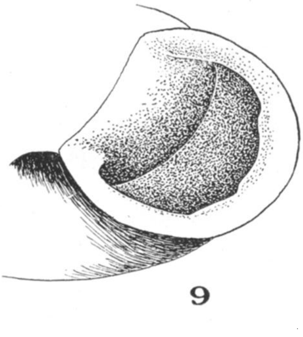
6



7

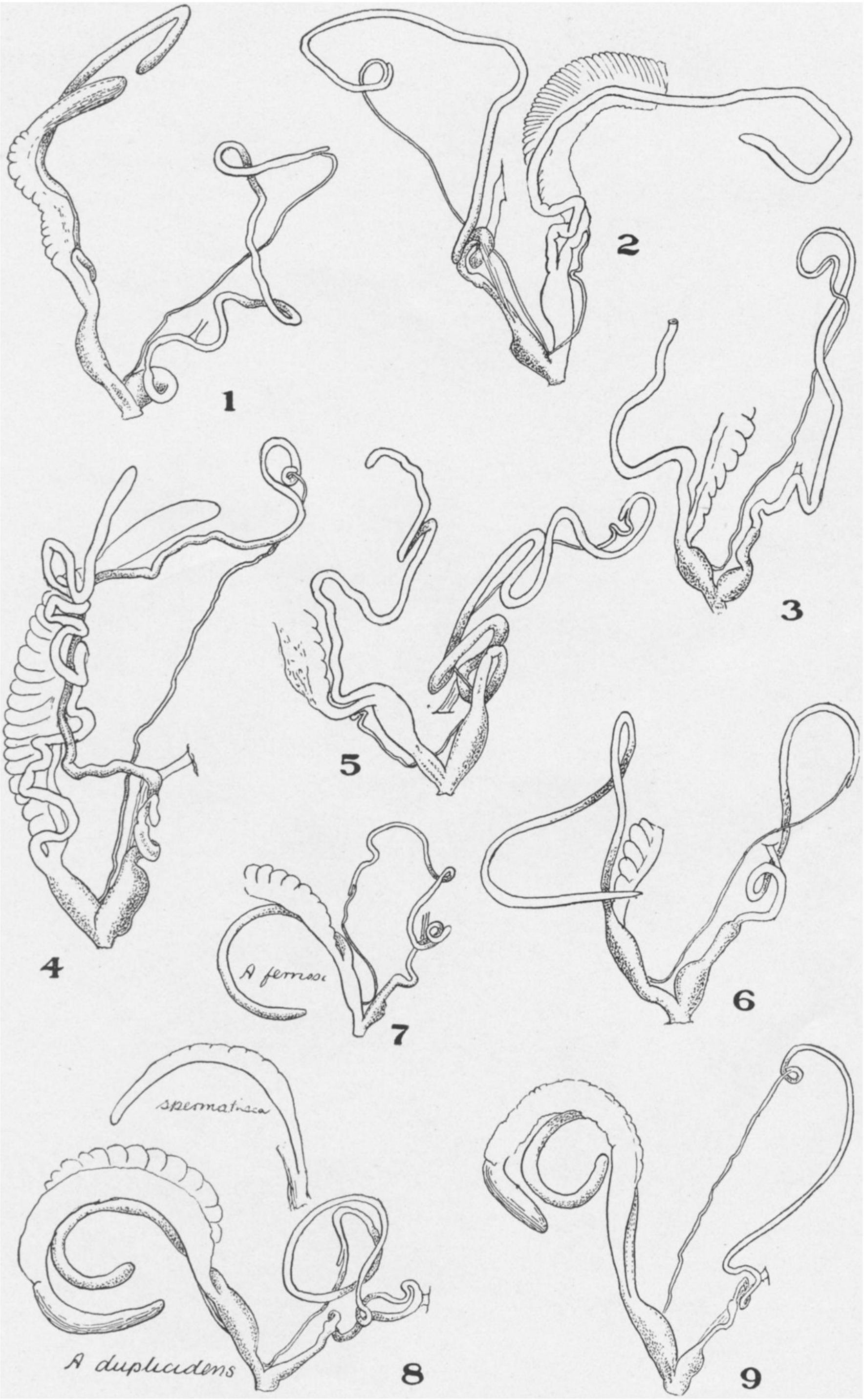


8

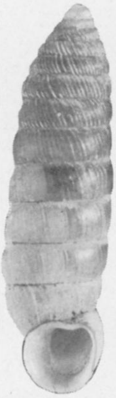


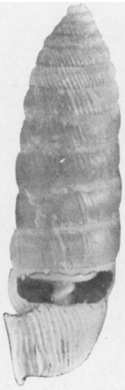
9

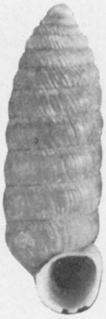
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.

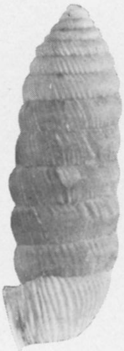


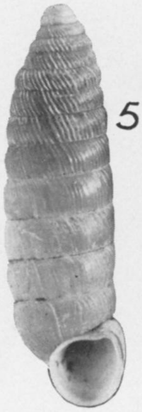
PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.

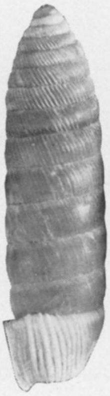

1

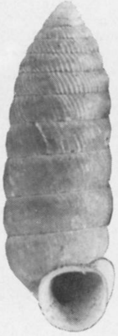

2

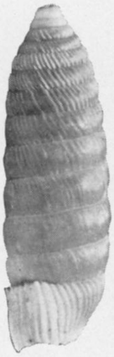

3

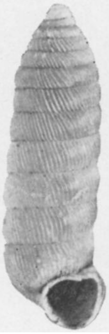

4

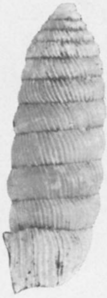

5

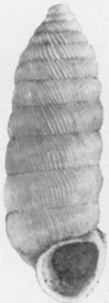

6

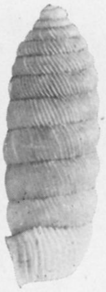

7


8

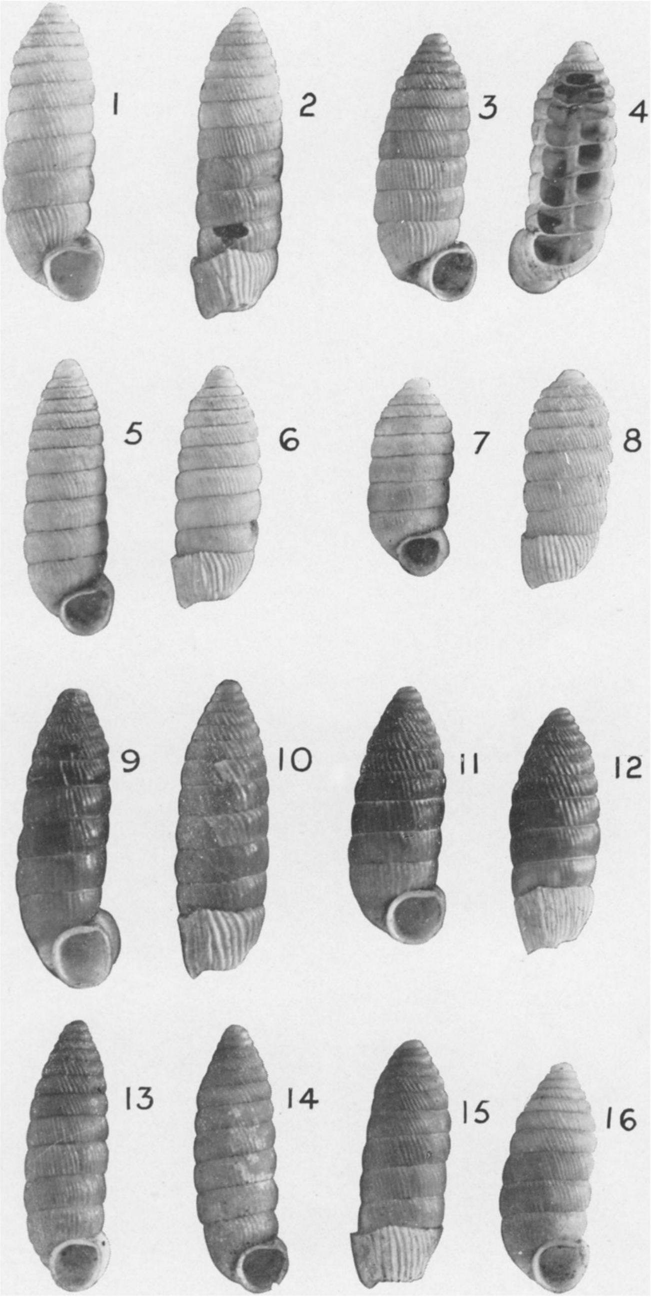

9


10


11

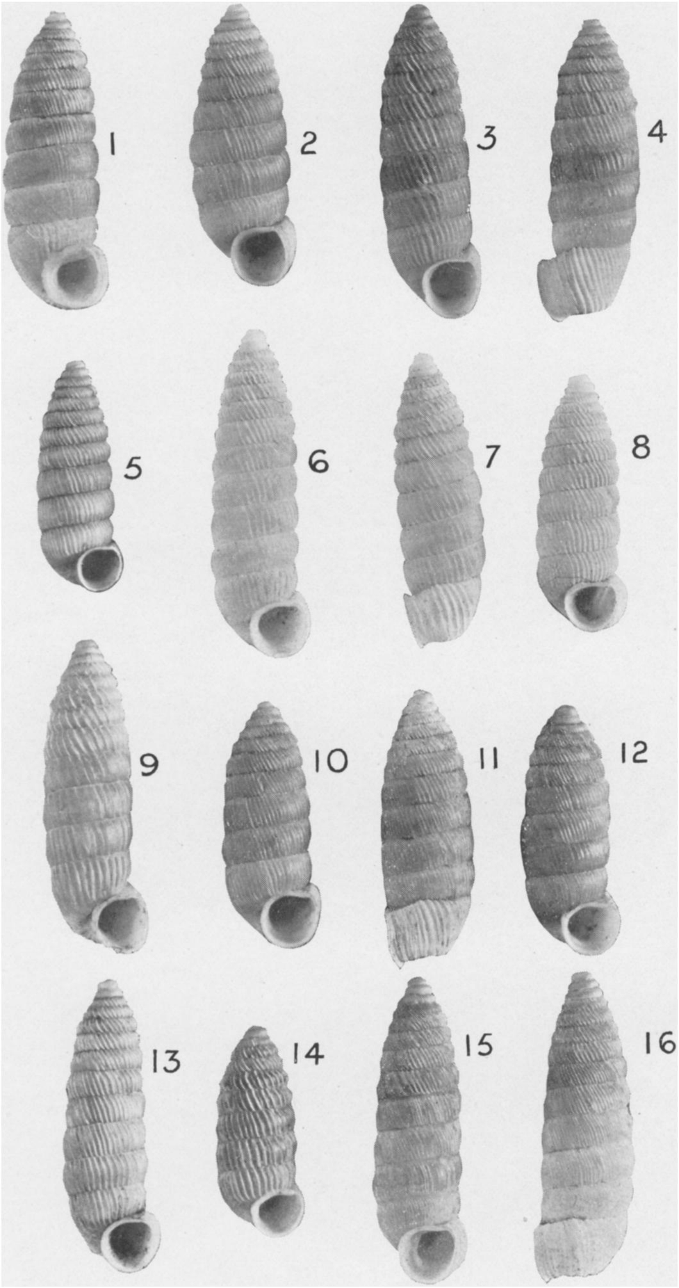

12

PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.

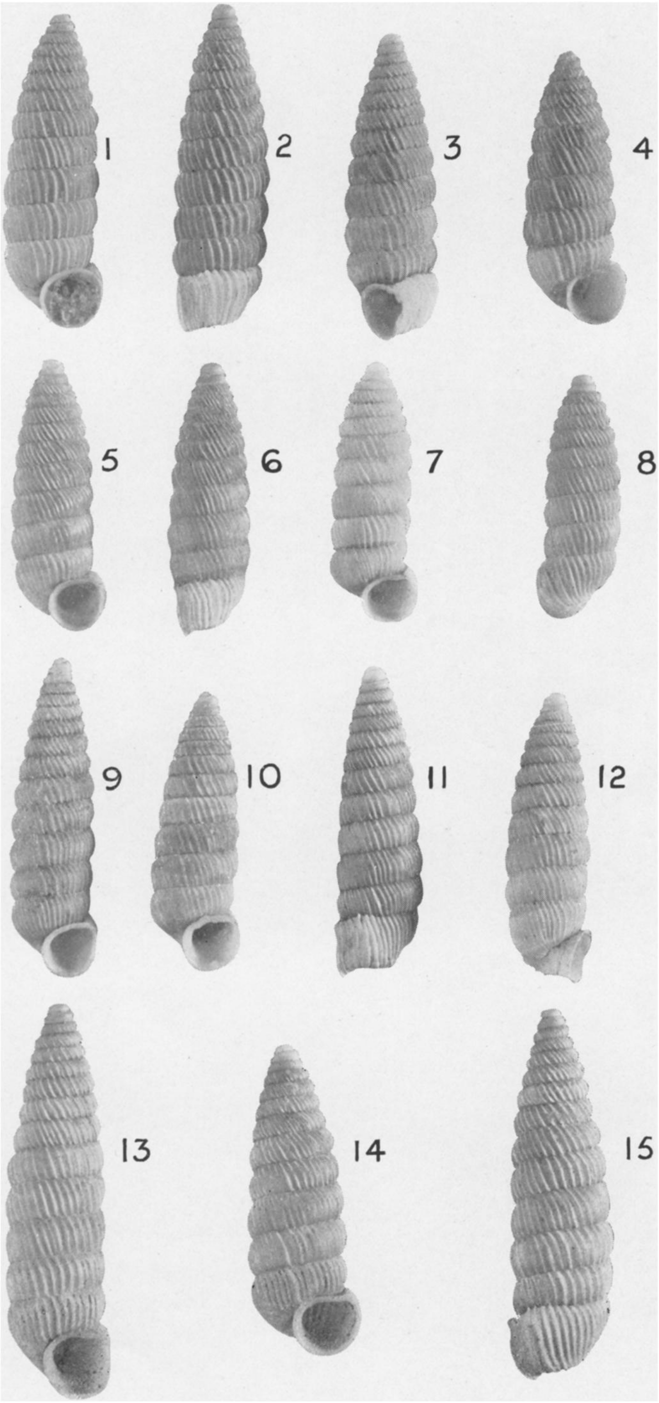


PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.

PLATE XIII.



PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.



PILSBRY AND FERRISS: MOLLUSCA OF SOUTHWESTERN STATES.